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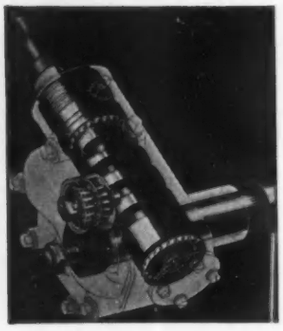
Ease of Wheel-Turn



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How To

Cut Costs, Improve Quality Shown at Production Meeting

Everything new in machine tool design was displayed at the National Machine Tool Builders' show, which automotive men attending the S.A.E. Production Meeting in Cleveland Sept. 18 and 19 visited and studied. The high spots of this big exhibit were described to the S.A.E. men by J. R. Cox, Thompson Products, Inc.

INSPIRED and stimulated from viewing "the greatest exhibition of mechanical art that the world has ever seen", as one speaker so aptly described the National Machine Tool Exhibit, almost 400 members of the Society of Automotive Engineers attended the two-day S.A.E. Production Meeting held at the Hotel Statler in Cleveland, Sept. 18-19, which served as the focal point for the automotive people who came and saw and stayed to ponder.

That the show provided a dominant and brilliant setting for the Society meetings was felt by all. Praise for the achievements of the machine tool builders was on every tongue. President William B. Stout, addressing the Production Dinner Session on Thursday evening, declared himself "extremely impressed by the show, not only because of the machines, the personnel and the show itself, but because of the feeling generated that here was the soul of the progress of humanity". Vincent P. Rumely, Hudson Motor Car Co. and vice-president of the S.A.E. Production Activity, toastmaster at the dinner held under the auspices of the Cleveland Section, declared the show to be wonderful and said "we regret we can't stay another week".

Members of the Society perhaps took more satisfaction in the show than any other group, unless it was the machine tool builders themselves, because it was obvious to all who attended that the automotive and machine tool industries were virtually one in spirit and accomplishment. J. R. Cox, Thompson Products, Inc., told members at one of the sessions that the interdependence of these two industries was everywhere apparent and the extent to which the machine tool builder had borrowed ideas from the automotive world was not possible to overlook.

President Stout, addressing dinner guests and not a few gallery spectators, surveyed the road to the future indicated by the striking exhibits just seen, entitling his talk "Where Do We Go from Here?" It was his contention that machines are solving moral problems of the world and that in making possible annihilation of time and space they are broadening men's outlook. Unrest, he said, is due to the urge of great changes coming about incident to the discovery of moral laws through human ingenuity and progress.

As a closing prophecy President Stout declared that everything being built today will be obsolescent in two years. Obsolescence now rules, he said, and we can look for twice as many changes in the next five years as we have seen in the past ten. These changes will not be in automobiles alone, but in highways, homes, lighting, cities and tools. Economics will enter more into tooling than ever before in order to handle this vital factor of obsolescence.

Willard C. Brown, illuminating engineer, Nela Park, and vice-chairman, Cleveland Section, served as chairman of the S.A.E. Production Dinner Session in the absence of A. T. Colwell, chairman of the Section, who was called away suddenly by a death in his family.

After listening to J. R. Cox, who presented a paper, "A Quick Trip to the Machine Tool Exhibit", most members probably felt that machine tool builders had pretty well anticipated developments more than two years ahead. Mr. Cox's paper was the first delivered at the Wednesday S.A.E. Session, which was run off with machine tool precision with Joseph Geschelin, Detroit Technical Editor, Chilton Co., in the chair.

Mr. Cox prefaced a survey of developments by saying:

"During the years of depression, automobile manufacturers, in their efforts to stimulate sales, have called on the machine tool builder for assistance in cutting costs. You have continuously fed their machines, demanding closer tolerances, harder materials and faster cutting speeds due to cemented

A. T. Colwell, chairman of the Cleveland Section, which cooperated in the arrangements for the meeting and helped to make it a success

carbide tools, until the old models couldn't take it any longer. But the tool builders have just shown us a new crop designed to take it, as well as put it out."

In summarizing his impressions of the show, Mr. Cox listed as important—more widespread use of nickel alloy iron of high steel content for beds and other cast parts, producing a stiffer, harder and better wearing job; greater use of anti-friction bearings—one turret lathe noted used over 50 tapered roller bearings, while a boring mill had over 70; general replacement of flat belt drives by multiple-vee belts; more pressure lubrication, making the oil can obsolete; almost universal replacement of tapered, friction clutches by disc clutches, almost universal use of hardened and ground gears with spiral teeth to produce silent equipment; greater popularity of fingertip or push-button control, reducing manual effort required for operation, and his final observation was the rise of power operated chucks and virtual disappearance of chuck wrenches.

In giving a more detailed account of machines at the show, Mr. Cox said:

"I noticed that several companies are showing machines designed for dressing cemented carbide tools and so constructed as to assist the operator in preserving the proper tool angles. Other companies are making diamond impregnated grinding wheels for grinding this material. This equipment makes it as easy and simple to sharpen carbide tools as it has been to sharpen conventional tools in the past."

Pointing out that surface broaching has wide possibilities in the manufacture of automotive parts for operations formerly performed by form milling, Mr. Cox cited as noteworthy a new centerless lapping machine with 24-in. wide wheel, for producing a mirror finish of extreme accuracy on cylindrical parts. He also cited a bolt-making machine which takes the iron wire from the coil, gathers the head by the double upset process, points the end and rolls the thread at the rate of 75 finished bolts per minute. And he noted that air-operated disc clutches were replacing the dog type clutch on heavy heading machinery and presses.

"Several manufacturers exhibited power units which should prove very useful in the automotive field", said Mr. Cox. "These units are capable of being used in either the horizontal or vertical position; they can be used as single spindle machines for doing boring, drilling, or tapping; for facing, counter-boring or milling. And they can be used to drive multiple drilling heads. The advantage of these power units is that when a manufacturer changes the design or shape of his motor blocks, or other parts, the unit is still serviceable for the new design with but slight changes in the fixture and drilling heads. In other words, you may construct your own special machine by using standard units.

"Centerless internal grinders were exhibited. This machine seems to have a wide application for plain hardened bushings, for sleeves, valve seats, etc. Many machines were exhibited for finishing gears. There were burnishing machines and lapping machines". Mr. Cox noted one new machine for grinding spiral bevel ring gears which produced at the rate of four minutes per gear, floor to floor time.

Another machine that caught his eye because of its possibilities for heavy work was a combination milling machine, planer and boring mill. Once a heavy casting is placed on this machine it can be finished almost without further handling.

Among other machines mentioned particularly by Mr. Cox were:

A machine equipped with an ammeter as standard equipment to tell the operator at all times what load the tool is pulling. It provides a warning against overloading and indicates to the operator the condition of the cutting tool.

A planetary type milling machine with possibilities in aircraft as well as the automotive field. A connecting rod machined by this planetary milling machine was finished on both sides and the bore of the large end in one operation.

A centerless grinder with gap type bed, especially designed for grinding the large end of connecting rods.

A machine featuring a tubular way, designed to absorb thrusts from any direction without the tendency of having the table lift off the bed. The tube part is hardened and ground and its interior provides an oil reservoir. The female way, which is part of the bed, is removable and renewable.

A turn milling machine where cylindrical pieces are milled on their diameters, the piece being rotated on its axis while two cutters feed in, one from each side, using the climb cutting principle. This machine seems to be very suitable for forgings such as front wheel spindles and universal joints which are generally irregular in shape, but have some cylindrical surfaces.

Machines equipped with anti-backlash devices on the feed screws.

A new automatic sizing device controlling the complete cycle of a grinding machine. This device projects a jet of air at the piece being ground and as the piece nears the desired size, its surface tends to close the orifice from which the air is emitted, increasing the back pressure on the air line, which in turn operates a mercury switch to control the functions of the machine.

A new universal milling machine in which the knee is mounted on a horizontal rail, providing the knee and table with a supplemental horizontal movement.

A shaper featuring a hydraulic drive—an ideal place for application of the hydraulic principle.

A new application of the Keller unit. The magic wand was tracing contours and reproducing them on a part being turned on an engine lathe.

"In spite of the fact that the machines you saw at the show are capable of increased production," Mr. Cox said, "they are so thoroughly designed with regard to ease of operation that the operators of these machines will be required to expend less physical effort per piece produced."

"Methods of Finishing Transmission Gears", a paper presented by S. O. White, chief engineer on development work, Warner Gear Co., and prepared in collaboration with Marley C. Hedgeland, discussed several available commercial methods of finishing gear teeth and pointed out the long way still to go. Mr. White said in part:

"It has been evident that it is necessary to produce a highly accurate tooth, in the green. In fact, with some shapes of gears that are favorable and with certain steels and heat treating methods, it does not seem to be necessary to perform any finishing operation on the hardened teeth, if they are highly accurate and smooth in the green. In other cases it is necessary to employ some lapping process on the hardened gear. The higher the quality of the green gear, the more satisfactory results do we get from the lapping and in less time. It is no exaggeration to say that the gear finishing operations begin in the steel mill and are carried along in the forge plant. It is then vital to have an accurately finished, true running blank on which to cut the teeth."

"Neither the prevention of fire distortion nor its satisfactory correction have yet been achieved. There is plenty of work ahead for the steel maker, the forger and the machine tool and cutter maker, with constant vigilance and painstaking care on the part of the gear maker, to get the most out of the tools that are at his hand".

V. P. Rumely, vice-president of the Society representing the Production Activity, was toastmaster at the dinner in Cleveland on Sept. 19

President W. B. Stout, speaker at the dinner, talked about what the future holds in automobile design

E. L. Bailey, elecrical engineer, Chrysler Corp., presented a paper on "Application of Induction Heating in Automobile Production".

Prefacing his address with the comment that electrical engineers have done everything possible to get rid of hysteresis and eddy currents and are now making use of them, Mr. Bailey cited paint drying as perhaps the latest practical process making use of induction heat and declared that tests showed paint drying from the inside out to be highly desirable since paint so baked has excellent adhesion and great durability. He warned, however, that he was not saying it was the best way in all cases.

"The production efficiency of the induction oven is very high as all the electric energy of the high frequency circuit is used inside the oven," said Mr. Bailey. "The part being baked is always the hottest spot in the oven. The air circulated and discharged to carry away the fumes of baking is low in amount and 40 deg. to 50 deg. lower in temperature than the parts, as is the oven temperature itself. So radiation is much less through the oven walls than in conventionally air heated ovens. Further, when no load is going through the coils, no power is being used except that due to the loss in the coils and walls, which is made to balance the radiation.

"The most successful control is a simple thermostat which operates the ventilation fan, for when no work is going through the oven, no fresh air is needed, and the fan is cut off. When new freshly painted parts move into the coils, heat is generated in the parts which not only drives off the vola-

tiles but raises the oven temperature which starts the ventilating fan."

Indicating the extent to which induction heating has been developed commercially, Mr. Bailey said:

"Brass companies are daily melting tons of non-ferrous alloys. The steel companies are producing large quantities of high melting point alloy steels. A large bicycle concern is baking the colored enamel on their bicycle frames and forks. Heat treatment of steel from hardening of safety razor blades to crank-shafts are daily production processes".

Asked by the Chairman what induction oven applications were in use in the Chrysler plant, Mr. Bailey listed the drying of the glyptal resin base on wheels, application to headlights, to lacquer on sheet metal, and to the drying of the entire body after the Bonderizing process where the conveyors move 8 ft. per min. and the job is done in 25 ft.

F. P. Spruance, vice-president in charge of sales, American Chemical Paint Co., talking on "Rustproofing and Paint Adherence Technique", gave a very comprehensive picture of the battle being waged against rust and the search for a cheaper process than that of zinc Granodizing or Electro-Granodizing, which led to experiments with chromates. In this connection he said, in part:

"The Chromodine process ideally meets the two requirements that experience has indicated are necessary to general application: low cost of operation; and excellent rustproofing for steel parts that will be subjected to bending and denting after painting. In addition Chromodizing efficiently protects the steel from the action of salt used in winter to prevent the formation of ice on the highways, an important cause of failure. The low cost of operation can best be realized when we understand that the cost for the treating chemical does not exceed ten cents per hundred square feet of surface treated.

"The simplicity, the speed, the low cost of Chromodizing, and the fact that this treatment seems as effective as soluble

(Concluded on page 23)

S.A.E. Nominees for 1936

FOLLOWING are the names of those who have been nominated as officers and members of the Council for 1936:

President ..... **Ralph R. Teetor**
In charge of Engineering, Perfect Circle Co.

Treasurer ..... **David Beecroft**
Manager, New York Office, Bendix Aviation Corp.

Councilors

Term of 1936-1937

Joseph A. Anglada
President, Anglada Motor Corp.

Louis Schwitzer
President, Schwitzer-Cummins Co.

Alex. Taub
Development Engineer, Chevrolet Motor Co.

Members of the 1936 Council will include also F. C. Horner, Assistant to Vice-President, General Motors Corp.; H. T. Woolson, Chief Engineer, Chrysler Corp.; and Austin M. Wolf, Consulting Engineer, New York; who were elected at the beginning of 1935 for a two-year term; and as Past Presidents, D. G. Roos and William B. Stout.

Vice-Presidents

Aircraft ..... **Mac Short**
Vice-President and Chief Engineer, Stearman Aircraft Co.

Aircraft-Engine ..... **Opie Chenoweth**
Research Engineer, U. S. Army, Air Corps, Wright Field

Diesel-Engine ..... **Fred M. Young**
President and General Manager, Young Radiator Co.

Fuels and Lubricants .. **T. B. Rendel**
In charge of Automotive Research Laboratory, Shell Petroleum Corp.

Passenger-Car ..... **Earl H. Smith**
Development Engineer, Packard Motor Car Co.

Passenger-Car-Body .. **Ronald J. Waterbury**
Body Engineer, Chevrolet Motor Co.

Production ..... **Karl L. Herrmann**
Vice-President, Bantam Ball Bearing Co.

Transportation and Maintenance ..... **Harley W. Drake**
Superintendent of Garage, Portland Gas & Coke Co.

Truck, Bus and Railcar ..... **Adolf Gelpke**
Assistant Chief Engineer, Autocar Co.

Tractor and Industrial Power Equipment .. *(In the absence of an earlier business session of this Activity, this nomination has been delayed pending selection of the Activity Nominating Committee at the Tractor and Industrial Power Equipment Meeting in Chicago, Oct. 11 and 12.)*

Deposits in White Metal Carburetors[1]

E. L. Baldeschwieler, G. M. Maverick and J. E. Neudeck
Esso Laboratories, Standard Oil Development Co.

SINCE the introduction of white metal die cast carburetors, complaints of stoppage of fuel flow by powdery material have been received more or less regularly. Frequently the claim has been made that the deposits were due to accumulation of precipitate from leaded fuels, although analysis showed it to consist mostly of zinc salts and it was shown to occur where non-leaded fuels were used. Such complaints were also most numerous during rainy periods. However, it generally happened that very incomplete histories could be gathered on individual cases, so that there remained some doubt as to whether the deposit was due to a fault in the fuel.

A survey was recently undertaken in two cities to determine what proportion of fuel complaints received by garages were due to deposits in carburetors or fuel systems. Out of 29 garages visited, none reported any troubles with the fuel tanks. Three garages reported the presence of red deposits in the fuel lines, and six others found fuel lines plugged with lint and other foreign materials. Red deposits in carburetors were found by two establishments, but ten reported the presence of white deposits in carburetors and fuel pumps. The presence of gummy material was reported in only one case. The survey therefore shows that the majority of the complaints were caused by white or red deposits on the die castings in the fuel system.

Recently, however, the opportunity arose to investigate an individual carburetor corrosion complaint on which a rather complete story had been obtained and the carburetor involved sent to the Esso laboratories. The conclusions derived were fully borne out by the fact that it was possible to reproduce the corrosion effect by laboratory experiments.

[1] This article has been authorized and is sponsored by the Fuels Research Subcommittee.

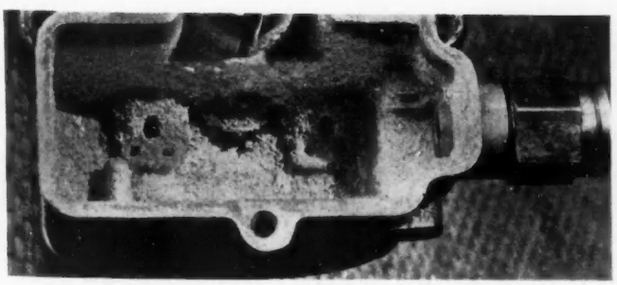


Fig. 1—Interior of the Carburetor Bowl with a Thick, Adherent Pinkish White Deposit

Table 1—Analysis of Deposit in Carburetor Bowl

	Per Cent
Lead oxide	1.20
Alumina and iron oxide (mostly alumina)	3.00
Zinc oxide	83.00
Lime	None
Magnesia	None
Silica	Trace
Water and organic matter	12.30
Water soluble	0.15
Chloroform soluble	Trace
Halogens	Small Amount
Sulphur	None
Total	99.65
Ash	87.70

The carburetor in question was attached to a 1934 passenger car which had run about 5000 miles, exclusively on premium grade gasoline. Recently the user had changed to a different premium fuel, and it was felt that the corrosion later observed was due to this change in fuel. The interior of the carburetor bowl was found covered with a thick, adherent pinkish white deposit. This is shown in Fig. 1. The composition of this material is given in Table 1.

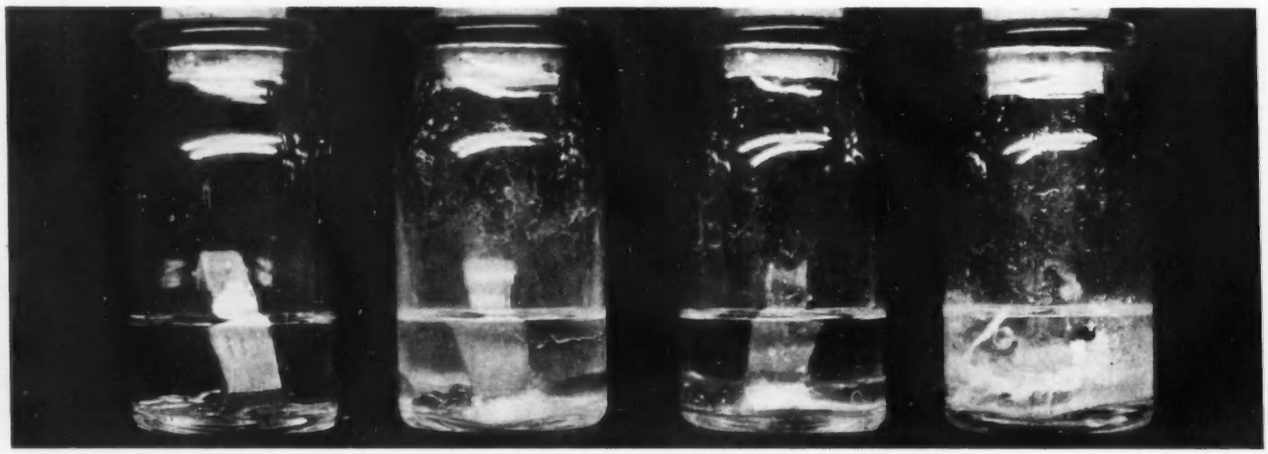
The pinkish color of the deposit was caused by a trace of the red gasoline dye. The presence of the small amount of lead oxide was ascribed to hydrolysis of the tetraethyl lead present in the gasoline, due to water which, as will be shown later, must have been present. The fact that practically none of the material was soluble in chloroform denotes absence of gasoline gum and organic substances other than carbon. The material contained only a small amount of carbonaceous material if any, as judged by the lack of darkening of the sample in the course of the ash determination. The water soluble portion showed presence of zinc, sodium, potassium and chlorine. These salts as well as the silica, iron and aluminum probably came from the air and may be accounted

for by the fact that this car ran mostly in Texas, a section of the country rich in alkali dust.

It is evident from the analysis that the deposit consisted largely of a mixture of zinc hydroxide and zinc oxide. An analysis of the carburetor metal showed it to consist mostly of zinc with a small amount of copper and aluminum. This was therefore undoubtedly a case of corrosion and it only remained to determine its nature. Corrosion by the gasoline was at once eliminated in view of the fact that while there are several millions of cars using leaded fuels, these types of corrosion have only been brought occasionally to our attention. Again gasoline corrosion is generally caused by the presence of corrosive sulphur compounds in the gasoline and this element was not present in the corroded material. For the above reasons and the fact that the zinc was present mostly as a hydroxide it was felt that the corrosion must have been due to the presence of water in the carburetor bowl. This theory was tested and verified by carrying out corrosion experiments with strips of the metal from the uncorroded part of the carburetor, in which they were subjected to the action of gasoline, water and mixtures of the two at ordinary temperatures.

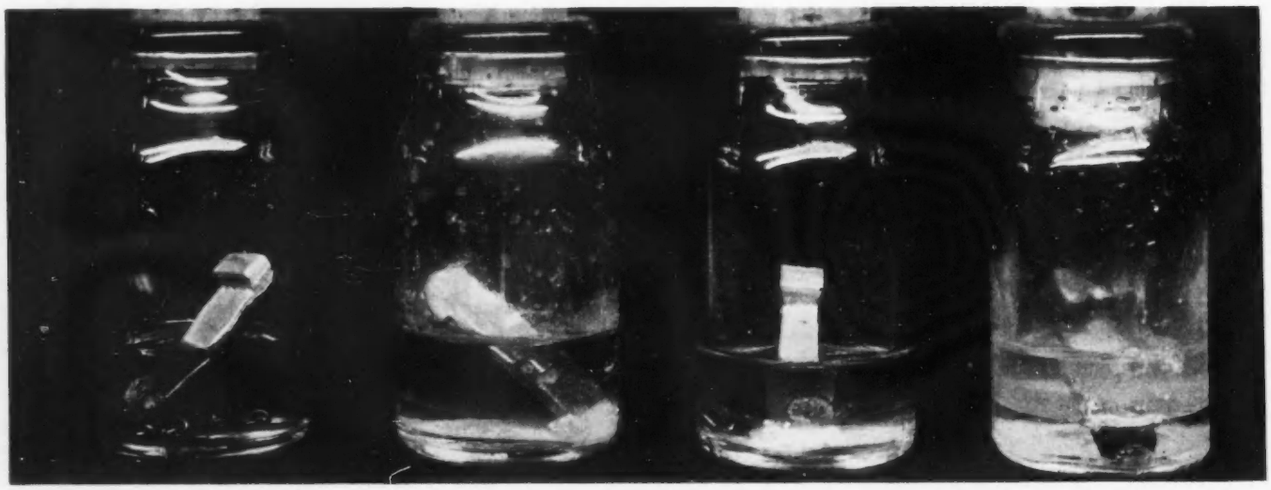
Briefly, the tests were carried out by placing the strips in small wide-mouthed bottles and the various liquids added until the strips were about half immersed. The bottles were uncorked and shaken two or three times every day so as to wet the whole specimen and the appearance of the strips and solutions noted. After three days a few links of brass chain were introduced into each bottle so as to simulate the effect of copper tubing and brass fittings and jets in the fuel system.

To determine if air was necessary to produce the corrosion, experiments were also conducted in a nitrogen atmosphere by first evacuating with a pump the tubes shown in Fig. 4



Non-Leaded Gasoline

1. Alone
2. With distilled water
3. With tap water
4. With sea water



Leaded Non-Premium Gasoline

1. Alone
2. With distilled water
3. With tap water
4. With sea water

Fig. 2—Photograph of Specimens Taken at End of 24 Days' Test

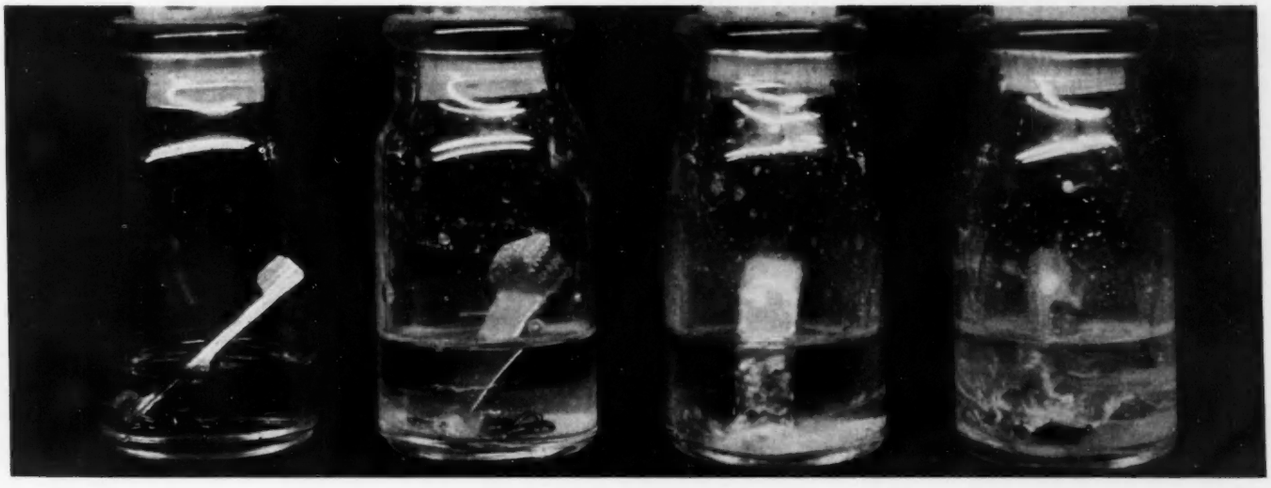
Table 2—Corrosion Tests with Gasoline-Water Mixtures on Carburetor Metal Specimen

Test No.	Liquid	Tests Without Brass Chain After 3 Days	Tests With Brass Chain After 1 Day	2 Days	3 Days	7 Days	24 Days
1	Non-leaded gasoline	A	A	A	A	A	A
2	Same + distilled water	C	C	C	D	D	D
3	Same + tap water	B	B	B	C	C	D
4	Same + sea water	B	B	B	D	E	E
5	Regular priced leaded fuel	A	A	A	A	A	A
6	Same + distilled water	D	D	D	D	E	E
7	Same + tap water	B	B	C	C	D	D
8	Same + sea water	B	D	C	D	E	E
9	Premium priced leaded fuel	A	A	A	A	A	A
10	Same + distilled water	B	C	C	C	D	E
11	Same + tap water	D	D	D	D	E	E
12	Same + sea water	D	D	D	D	E	E
13	No. 9 in nitrogen	Not Started	A	A	A	A	A
14	No. 10 in nitrogen	Not Started	A	B	B	C	D
15	No. 11 in nitrogen	Not Started	A-B	B	B	C	D
16	No. 12 in nitrogen	Not Started	B	C	C	D	D
17[a]	Distilled water alone	A (1 day)	C (5 days)	—	—	D	E
18[a]	Tap water alone	B (1 day)	E (5 days)	—	—	E	E
19[a]	Sea water alone	E (1 day)	E (5 days)	—	—	E	E

[a] Tests with water alone were carried out without brass chains throughout.

Water Alone

17. Distilled 18. Tap 19. Sea



Premium Priced Leaded Fuel

9. Alone 10. With distilled water 11. With tap water 12. With sea water

Fig. 3—Photograph of Specimens Taken at End of 24 Days' Test

and then introducing nitrogen from a cylinder. The tests and appearance of the specimens are described in Table 2. The pictures in Figs. 2, 3 and 4 were taken at the end of the 24 days' test. The condition of the specimens at the end of the tests is shown in Fig. 5. The specimens were examined periodically and were rated, according to their appearance, extent of corrosion and amount of precipitate, as follows:

(a) No corrosion.
(b) Very slight corrosion.
(c) Definite corrosion, white spots appearing on the surface, slight precipitation.
(d) Bad corrosion, surface completely attacked, heavier precipitation.
(e) Very bad corrosion, surface completely attacked, heavy white precipitate at the bottom of the bottle.

The tap water used in these experiments was Elizabeth, N. J., city water, which has a high alkalinity and a temporary hardness of over 100 parts per million, calculated as calcium carbonate.

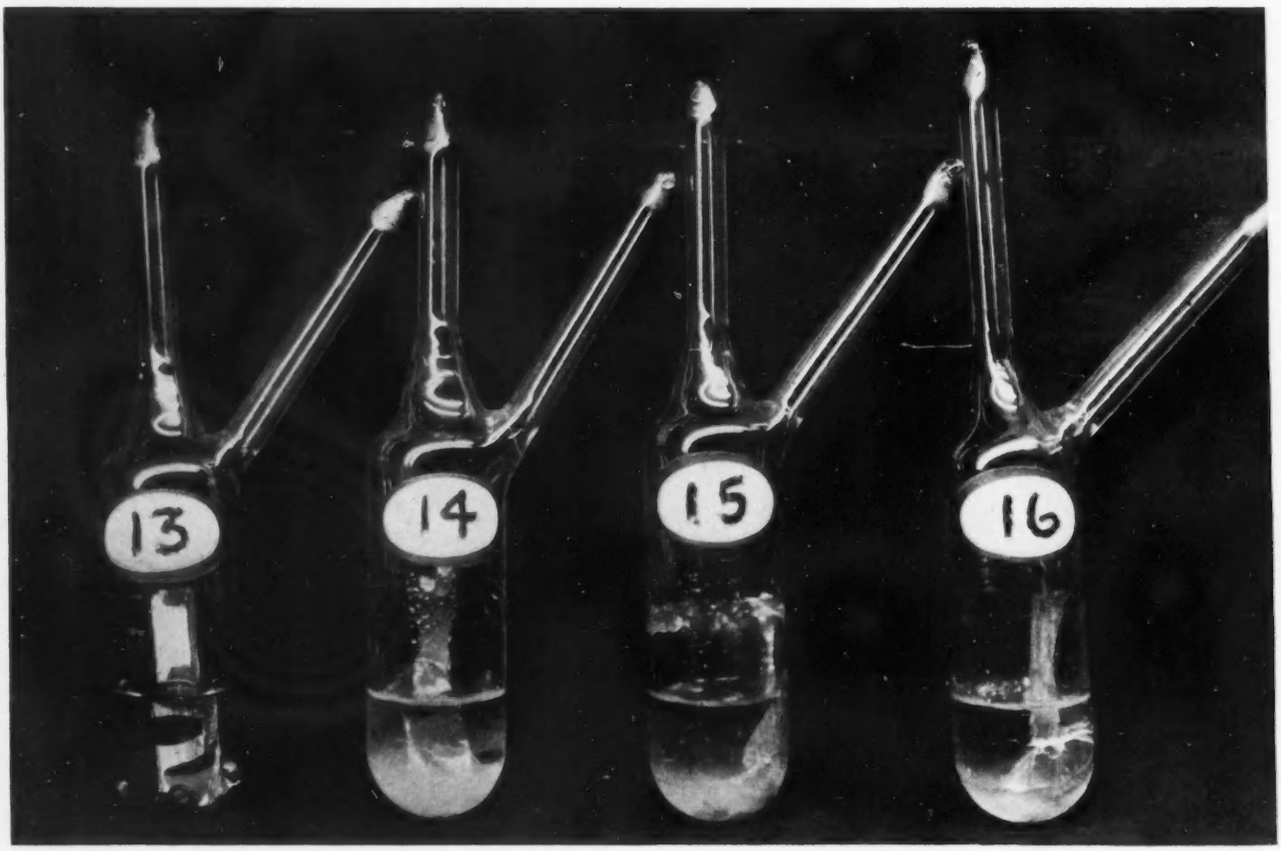
In order to check up on the composition of the carburetor sediment given in Table 1, an analysis of one of the precipitates in the bottles was carried out. The precipitate was filtered off, washed with distilled water and dried at 100 deg. cent. overnight. It was found to contain 16 per cent of water, the remaining 84 per cent consisting of practically pure zinc oxide. This shows definitely that this material has the same composition as the carburetor sediment.

Conclusions

From the tabulated results the following conclusions can be drawn:

1. Gasoline alone, either leaded or non-leaded, is not responsible for or contributory to the corrosion.
2. The corrosion is due to the action of water on the metal.
3. This corrosion takes place even after *practical* removal of oxygen and with distilled water.
4. The presence of either oxygen or salts or both accelerates the corrosion.
5. Electrolytic action seems to play a minor part.
6. The presence of gasoline retards the corrosion; possibly by preventing access of the oxygen to the water layer.

It is evident that the accidental presence of water in the carburetor, and not the gasoline, was the cause of the corrosion. It follows that any other white metal (in the pump for instance) or galvanized part in the fuel system will be subjected to the same type of corrosion in the presence of



Premium-Priced Leaded Fuel in Nitrogen Atmosphere

13. Alone
14. With distilled water
15. With tap water
16. With sea water

Fig. 4—Photograph of Specimens Taken at End of 24 Days' Test

Fig. 5—Condition of Specimens at End of Test

water, with the added danger of electrolysis in the case of galvanized iron. This explains the occasional presence of red deposits in fuel tanks, lines and even carburetors, inasmuch as fuel tanks of some cars are made of galvanized iron. In this case the presence of water in the tank first corrodes the zinc, as illustrated above; as soon as the corrosion has penetrated sufficiently to uncover the iron, the zinc plating forms a battery and the rate of corrosion will be greatly increased, mostly at the expense of the iron with formation of red ferric hydroxide. The resulting mixture of iron and zinc hydroxides is easily detached and may be carried into the line and carburetor by the fuel.

Since the introduction of water in the fuel systems of automobiles, either accidental or through condensation, cannot be prevented, immediate steps should be taken to prevent future troubles by the exclusion of white metal or galvanized parts in the construction of the fuel systems unless suitable protective coatings are used. It is understood that recent work by the carburetor manufacturers has shown the practicability of obtaining such protection. Sediment bowls to collect any water or sediment which may be carried from the tank should be of value, and fuel pumps should not be designed with low spots capable of trapping out water.

Existing cars subject to the present corrosion difficulties are best taken care of by frequent inspection and cleaning up of the system.

Regional Transportation Meeting

Sponsored by the Metropolitan Section, S. A. E.

Newark, N. J., Oct. 29, 30, 31 and Nov. 1, 1935

(Robert Treat Hotel)

PROGRAM OF SESSIONS

Tuesday, Oct. 29, Banquet

JOSEPH B. EASTMAN, Federal Coordinator of Transportation

Governor HAROLD G. HOFFMAN of New Jersey

ROY F. BRITTON, director, National Highway Users Conference

RALPH R. TEETOR, S.A.E. presidential nominee; DAVID BEECROFT, Past President; T. C. SMITH, Vice-President, Transportation & Maintenance Activity; F. C. HORNER, Councilor; T. V. RODGERS, President of American Trucking Association, and other notables are expected to be present at the banquet.

Wednesday, Oct. 30

Afternoon Session—Interstate Commerce Commission Regulation
(Speaker to be announced later)

Evening Session—Service Problems
Speakers: O. M. BREDE, G. M. Truck Co.
Invited Speakers: CLINTON BRETTELL, T. L. PREBLE

Thursday, Oct. 31, Highway Session

Speaker: JAMES SHANLEY, chief inspector, Motor Vehicle Division, State of New Jersey
Subject: "Motor Vehicle Inspection"

Afternoon Session—Fuels & Lubricants
Speaker: T. C. SMITH
Invited Discussers—SIDNEY J. WILLIAMS, National Safety Council; GEORGE WELLINGTON, Pres., American Association of Motor Vehicle Administrators

Friday, Nov. 1, Afternoon Session—Diesel Power

Speaker: C. R. KELLEY, Waukesha Motor Co.
Subject: "The Operation & Engineering Problems of the Injection Engine"
Invited Discussers—Hercules and Cummins Mfg. Co. have been invited to send representatives to discuss this paper

Evening Session: Tires & Springs
Speakers: S. WARD WIDNEY and DR. B. J. LEMON
Subject: "Tires, Springs and Shock Absorbers Testing Developments"

SAFETY RALLY

Held in Public Service Auditorium
FRED. C. ROSSLAND

Oct. 29—Second Annual Motor Truck Show—Nov. 2

Central Market, Newark, N. J. (Adjacent to Robert Treat Hotel)

The S.A.E. Regional Transportation Meeting will be held during the Second Annual Truck Show in Newark, sponsored by the New Jersey Motor Truck Association, Newark Chamber of Commerce and the New Jersey Highway Users Conference. The Metropolitan Section of the S.A.E. is cooperating with the Show, and those attending the Regional Transportation Meeting will have adequate opportunity to inspect the new trucks and equipment to be shown.

Governor Hoffman has proclaimed the week of the meeting and truck show as "Motor Transportation Week in New Jersey".

How to Cut Costs, Improve Quality Shown at Production Meeting

(Concluded from page 16)

phosphate coatings for actually preventing rust under paint, commands our attention. The unusual adhesion and flexibility of paint to Chromodized metals provides a protection from the wear and tear of service that compares favorably with that of the Electro-Granodizing process, and because of its flexibility seems to approach more nearly than any other, the perfect rustproofing of Granodized zinc. These factors, in particular the low cost of the process, open the field to the treatment of countless steel products that previously have been denied corrosion protection. The Chromodine process, designed for and used with excellent results to treat cold rolled steel to prevent rusting under paint, is surprisingly effective in accomplishing the same result on hot rolled or forged steel, and on castings."

In the discussion which followed, an interesting relationship between induction heating and rustproofing was brought out by W. B. Hurley, sales engineer, Detroit Edison Co. According to Mr. Hurley, an experimental test is being made of induction heating in the handling of wheels by Budd. The parts are cleaned, rinsed, heated in an induction oven to dry and while still hot are dipped into a tank with activated phosphates, then heated again, dried and painted, the entire process using induction heat. Tests, he said, seem to produce a better finish, quicker and cheaper, and the method lends itself well to conveyor systems.

V. P. Rumely declared that the change-over from enamel to lacquers added a considerable burden to automobile manufacturers to prevent rust and that there is a widespread interest in solving the problem. Since automobiles in the hands of users develop rust first at vibration points and vibration has never been completely overcome, there is great need for rustproofing these points. Mr. Rumely stated that there was a strong popular swing toward use of rust-resisting materials for surfaces.

Progress in resistance welding was given very thorough-going treatment by J. A. Weiger, chief metallurgist, P. R. Mallory & Co., Inc., in his paper entitled, "Resistance Welding in the Automotive Industry". Mr. Weiger stressed the use of automatic machines and the importance of proper tip material. He said in part:

"One of the most important advantages of automatic operation is the elimination of operator fatigue, thereby maintaining production at a high level with better satisfied operators, and in addition the results are more uniform welds, faster operation, better and smoother welds, lower current consumption and longer electrode life.

"One of the most essential parts of the resistance welding machine is the die or electrode material. Originally copper was used, but it was soon found on many of the automatic machines to have too short a life to produce the necessary results. For spot welding there are available today a number of alloys which have a life of three to twenty times that of copper. Experience indicates that for spot welding cold rolled steel a very high electrical conductivity is desirable, and it has been found that the alloy used for spot welding tips should have a conductivity of at least 75 per cent that of pure copper, and a hardness from 56 to 58 Rockwell 'B'.

"The correct pressure for spot welding cold rolled steel is approximately 15,000 lb. per sq. in. of electrode area. As the tip mushrooms, the pressure decreases and the current density decreases. After a certain time poor welds will result. Many shops do not allow the machine operator to dress his own tips, but have tool men to replace the tips which are re-machined off the machine. This gives an opportunity to have the tip made exactly to the desired size and shape and at the same time the proper pressure can be adjusted.

"The one striking fact which stands out is that in this field increased speed has not been detrimental to the results obtained. In practically all cases where the production rate has been improved, better welds have also been secured. It is no wonder that the manufacturers and the public have accepted electric resistance welded construction as the most up-to-date and satisfactory kind of construction."

S. A. E. Pacific Regional Meeting

San Francisco, Calif., Nov. 18 & 19
Hotel Whitcomb

Auspices of the S.A.E. Pacific Coast Sections

S.A.E. Professional activities cooperating on program

Papers and plant visits of interest to members in the fuels & lubricants, tractor, Diesel and transportation & maintenance fields

If you are going to be on the Pacific Coast at the time of the meeting—if you are a Pacific Coast member—

▶ ▶ ▶ ▶ Plan to attend!

TWO GENERAL MEETINGS OF UNUSUAL INTEREST

Transportation & Maintenance — *Tractors & Industrial Power*

Oct. 10 — Chicago — Oct. 11 & 12

(Palmer House)

TRANSPORTATION MEETING

THURSDAY, OCTOBER 10

Chairman, L. V. NEWTON

2:00 P.M. *Truck and Bus Tire Session*

(Auspices, S.A.E. Truck, Bus and Railcar Activity)

"When is a Truck Tire Overloaded?"—
J. E. HALE, Firestone Tire and Rubber Co.

8:00 P.M. *Motor Truck Loading Session*

Chairman, F. L. FAULKNER

(Auspices, S.A.E. Transportation and Maintenance Activity)

"Economical Loading of Motor Trucks"—
A. J. SCAIFE, White Motor Co.

The members of the Tractor Activity and of the Society have been cordially invited by the Farm Equipment Institute through their Secretary Robert A. Jones, to attend sessions of the F.E.I. at the Blackstone Hotel, in Chicago, during their 42nd Annual Convention, Oct. 9-10, 1935. This invitation applies particularly to their session on Thursday morning, Oct. 10, at which Harper Sibley, President of the Chamber of Commerce of the United States, will be the speaker. His topic will be "The Future of the American Farm and Its Place in the Business Picture."

TRACTOR MEETING

FRIDAY, OCTOBER 11

9:00 A.M.—Business Session—Tractor and Industrial Power Equipment Activity—
Vice-President, C. G. KRIEGER, Chairman

Engineering Research Session

Chairman, C. E. FRUDDEN

Greetings by
R. R. TEETOR, Presidential Nominee, Society of Automotive Engineers
W. C. MACFARLANE, President, Farm Equipment Institute
"Research in the Automobile Industry"—
T. A. BOYD, General Motors Research Corp.

2:00 P.M. *Metallurgy Session*

Chairman, L. B. SPERRY

"Metallurgical Aspects of Tractor Gear Sets"—
H. W. MCQUAID, Republic Steel Corp.

SATURDAY, OCTOBER 12

9:00 A.M. *Transmission Session*

Chairman, ELMER MCCORMICK

Greetings by W. B. STOUT, President, Society of Automotive Engineers
"Recent Tractor Transmissions and Their Trends"—
OTTO R. SCHOENROCK, O. R. S. Engineering Co.
"Some Thoughts on Present-Day Automobile Transmissions"—
A. W. FREHSE, Chevrolet Motor Co.
S. O. WHITE, Warner Gear Co.

Early reservations are desirable because of the presence of other conventions in Chicago on the same dates. An unusual opportunity to attend two general meetings of the Society, with many topics of related interest. Make your reservations direct to the Palmer House, Chicago

OFFICERS OF PARTICIPATING ACTIVITIES AND SECTION

Tractor

C. G. KRIEGER, Vice-President & Committee Chairman
A. W. LAVERS, Vice-Chairman
ELMER MCCORMICK, Chairman, Meetings Committee

Truck, Bus & Railcar

C. O. GUERNSEY, Vice-President & Committee Chairman
A. W. SCARRATT, Vice-Chairman
L. R. BUCKENDALE, Chairman, Meetings Committee

Transportation & Maintenance

T. C. SMITH, Vice-President & Committee Chairman
F. L. FAULKNER, Vice-Chairman
A. M. WOLF, Chairman, Meetings Committee

Chicago Section

R. T. HENDRICKSON, Chairman
F. L. FAULKNER, Vice-Chairman

Further Progress in Controlled Cooling of Radial Aircraft Engines

By J. M. Shoemaker, T. B. Rhines and H. H. Sargent, Jr.

DURING the last year studies by subsidiaries of United Aircraft Corp. on cowls for radial air-cooled engines have been continued in the wind tunnel and in flight. Model tests comparing the performance of fixed cowls under various conditions are reported, and further research on flapped cowls for controlled cooling is described.

Tests were made over a wide range of flap angles to show the possibilities of this type of cooling regulation, and a new form of cowl with flaps located well behind the engine at the fuselage firewall was studied. Flight tests with such a cowl showed that the qualitative variations indicated in the wind tunnel adequately represent full-scale conditions. The results of these flight tests are described in some detail.

An attempt is made to reduce the various wind-tunnel results to a form suitable for estimation of cowl characteristics for design purposes, and the results of this work are correlated with information obtained in flight.

The paper then discusses the structural design of flapped cowls and includes data relative to the air loads on flaps and to the resulting flap-hinge moments. A powerplant installation with flapped cowl is described in detail. It incorporates a novel operating linkage to control flaps located at the firewall. No inner or wrapper cowl is included, but an exhaust-manifold shroud prevents overheating of the accessory compartment and provides a supply of hot air for the carburetor.

THE remarkable strides made by designers of commercial and military aircraft during recent years have been most strikingly evidenced by the ever-increasing performance of their products. This progress has been gained, to a great extent, in two ways: by improving the aerodynamic cleanness of the airplane and by increasing the specific power output of the engine. However, the successful utilization of both methods has been complicated by the difficulty of providing the higher-powered engines with proper cooling and accessibility while retaining the cleanness of the airplane. Each addition to the powerplant output has not only further complicated that unit and made necessary more controls and accessories but has also made the engine harder to cool. Designing the cowl to favor the cleanness of the airplane has often proved to be detrimental to both proper cooling and accessibility.

Last year, the results of coordinated research by subsidiaries of United Aircraft Corp. on the subject of cooling and cowling were described in a paper[1] presented to the Society. That paper first traced the development of close or pressure-type baffles and explained their value. The pressure baffle, closely fitted to the engine cylinders, serves the three functions of preventing the flow of air through the engine disc except at points adjacent to the cooling fins, increasing the velocity of the existing flow and distributing that flow to the best advantage. It was concluded that baffle development had reached a point of efficiency where a marked improvement through basic changes in the baffle design will be difficult. Next was considered the proper cowling of the engine, particularly the baffled engine. It was shown that the drag of a cowled engine is largely dependent on the flow of cooling air through the baffles. Wind-tunnel tests of various cowl forms were described. Using the word "efficiency", meaning the amount of flow a cowl permits in relation to the amount of drag it causes, and the word "effectiveness", meaning the ability of a cowl to produce flow, the effects of cowl modifications were discussed. Thirdly, the possibilities of controlled cooling through the use of a cowl equipped with flaps to vary its effectiveness were explained. The results of wind-tunnel and flight tests were introduced to demonstrate the feasibility of such methods.

The value of controlled cooling was illustrated so clearly

[This paper was presented at the Semi-Annual Meeting of the Society, White Sulphur Springs, West Va., June 17, 1935. Mr. Shoemaker is connected with the Chance Vought Corp.; Mr. Rhines, with the United Aircraft Corp.; and Mr. Sargent, with the Pratt & Whitney Aircraft Co.]

[1] See S.A.E. JOURNAL, May, 1934, p. 147; "The Cowling and Cooling of Radial Air-Cooled Aircraft Engines", by Rex B. Beisel, A. Lewis MacClain and F. M. Thomas.

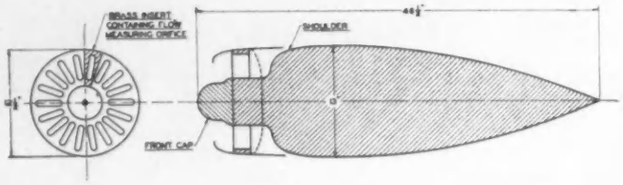


Fig. 1—General Arrangement of Quarter-Size Wind-Tunnel Apparatus

by those tests that the research has been continued. Additional wind-tunnel tests have been performed to investigate more fully the merits of certain cowl forms, particularly cowls equipped with flaps. An improved type of flapped cowl has been flight tested. In this paper are given results of these later tests; an attempt is made to present the material of the wind-tunnel tests in a form suited to the estimation of full-scale-cowl characteristics, together with the correlation of such an estimation with actual results; and the advantages and problems of the flapped cowl are analyzed from the manufacturer's viewpoint.

Table 1—Corrected Performance of the Model at 40 M.P.H. Engine-Baffle Diameter = 12⅞ In.

Maximum Nacelle Diameter, In.	Drag of Engine Nacelle Combination, Lb.	Airflow Through Baffle Cu. Ft. Per Min.
9	1.47	780
13	1.15	670
15⅝	1.19	660

Wind-Tunnel Tests of Cowl Models

The earlier paper included in its survey of the cooling problem the results of a number of tests which indicated many of the characteristics of efficient radial-engine cowls. To settle a number of additional questions on the design of cowls in general and of flapped cowls in particular, more wind-tunnel tests have been conducted. Fig. 1 shows the arrangement of the apparatus. It was generally the same as before and its design and use have therefore already been described. Measurements of the airflow under the cowl were made by means of the baffle representing the engine, and the overall drag of the cowl-nacelle combination was determined for each of a number of cowl designs. In these tests, some minor changes from the original model condition were incorporated. The differences in test results which followed from these changes will be discussed later.

Nacelle Diameter.—One of the unsettled questions in engine-cowl design has been the influence of the diameter of the nacelle or fuselage behind the engine in determining the drag and cooling characteristics of the engine-nacelle combination. It has been the general belief of designers that not only is engine drag reduced when the nacelle diameter is increased, but, up to a certain point, the overall drag of the combination is also reduced. To investigate this question, tests were made using one baffle in combination with three nacelles of various diameters. For each nacelle a cowl was designed in accordance with the best information available from the earlier wind-tunnel tests. When the resulting data had been corrected to comparable horizontal-buoyancy and tunnel-obstruction conditions, it was found that past beliefs were properly founded only when comparing the *same cowl* on the different nacelles. When the comparisons were made on the basis of drag at a given cooling-air flow, these conclusions no longer held. Table 1 shows the corrected performance of the model at 40 m.p.h. for a typical case in which the cowl is comparable in general dimensions to a Townend ring. Note that, although the drag decreases with increase in nacelle diameter, so does the flow.

The correct method of comparison is shown in Fig. 2, where model drag is plotted against model airflow for each of the three nacelles. Variation in flow was obtained by changes in skirt length and angle. It is plain that, for most conditions, the overall drag is least with the small nacelle.

The drag of a streamline body decreases as its diameter is reduced; in these tests, therefore, that part of the total drag chargeable to the body alone must have decreased. The added drag chargeable to the cowled engine may well have been greater in front of the small nacelle. No measurements were made of the drag of these nacelles without the engine in place, but if a reasonable drag coefficient for the streamline body be assumed to apply to each of the nacelles, the drag chargeable to the engine may be estimated. The results of this operation appear in Fig. 3. The two curves apply for two constant values of airflow. The lower curve is typical of complete N.A.C.A. cowls, while the upper curve is more nearly representative of short Townend rings.

Bumped-Out Cowls.—While the results obtained from variations of nacelle size showed no promise of large drag reductions, it was of interest to learn the effects of reducing the frontal area of the cowl on a given engine. It is not an unusual practice at present to make the inside diameter of the cowl ring considerably smaller than the overall diameter of the engine, with protuberances around the cowl circumference to provide space for the valve rocker-mechanism. This condition was simulated in the wind tunnel by building a cowl and equipping it with eighteen streamlined "bumps"

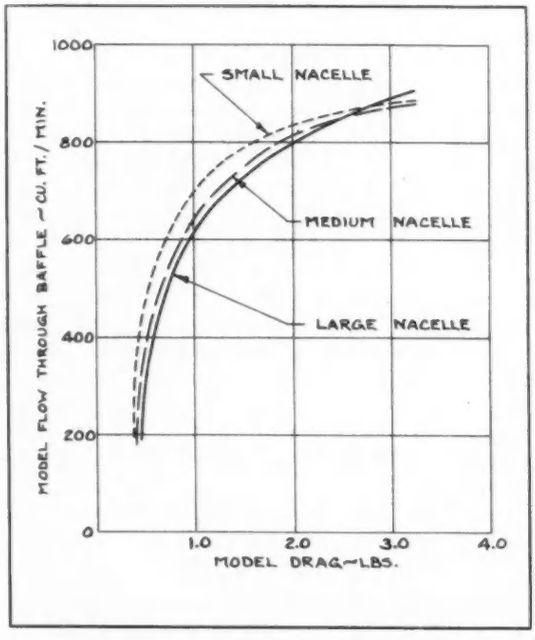


Fig. 2—Effect of Nacelle Size on Overall Efficiency

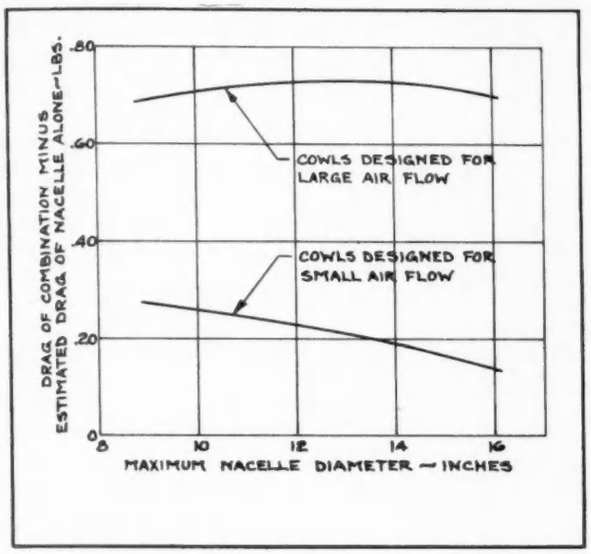


Fig. 3—Influence of Nacelle Size on Drag Due to a Cowled Engine

around its circumference. It was then compared with a generally similar cowl whose diameter was equal to that of a circle circumscribing the bumped-out model. There were found to be no important differences in aerodynamic efficiency between the arrangements. It thus appears that the cowl with the smaller frontal area may be used without harm when an improvement in vision over the nose of an airplane is worth the increase in cost of manufacture.

Cowl-Flap Arrangements.—The flapped cowl for controlled cooling as first proposed offered certain mechanical difficulties, particularly as regards the necessity for linking together a large number of small flap sections to operate as a unit. It was therefore felt wise to investigate briefly the possibility of using flaps made in a small number of larger sections; and, in this connection, tests were made on a cowl which incorporated four doors, each covering 70 deg. of the engine circumference. The four fixed parts of the cowl skirt extended back to close the exit gill. Each of the doors was hinged at two points on the cowl so that, when it was opened to small angles, a gap was left ahead of the hinge line; but, at an angle of 60 deg. this gap was closed. The results with this apparatus were not encouraging. It offered considerably more drag at any given flow than did the continuous flap arrangement.

In the same connection and with similar results a cowl with a single opening was tried. This, in addition to showing lower efficiencies than either the continuous flaps or the floor-door type, caused uneven distribution of cooling-air flow around the engine circumference. It would thus be expected that only part of the cylinders of an engine with this type of cowl would be adequately cooled, particularly if pressure baffles were not used.

Attempts also were made to find some means by which high-volume flows, such as are obtained with the flapped cowl, could be had without so much accompanying increase in drag. No appreciable improvements were obtained. It was found, for instance, that when a narrow Townend ring with an airfoil cross-section surrounded the trailing edge of a flap in the open position, the best that was done was to avoid harming the relative drag and flow characteristics.

Effect of Large Flap Angles.—All of the foregoing tests were run to investigate various interesting possibilities in engine cowling, but the primary object of continuing the general research on this subject was to learn more about the characteristics of the normal type of cowl flaps. In this connection a series of cowls having flap angles as high as 120 deg. was tested. Fig. 4 shows the general proportions of the model, and Fig. 5 represents the general curves of model drag against model flow for this study.

It was found, as in the earlier tests, that with complete flaps on one basic cowl form a given flow results in almost the same drag whether the flow be obtained by reducing the length of the skirt or by increasing the flap angle. In this case the cowl was tested with at least two flap lengths at each angle. For comparison, Fig. 5 also includes the characteristic curve obtained with the basic cowl-nacelle combination that was studied in the earlier paper. It would appear that the present flap design is somewhat inferior, but the difference was shown by test to be due, not to inferiority in cowl design, but to a change in the shape of the nose block ahead of the engine-baffle.

The first tests employed a model having a nose of comparatively small cross-sectional area, which faired with a reverse curve into that part of the combination which would represent the engine crankcase. In the present tests this reverse curve was missing. The broken line of Fig. 4 shows approximately the form of nose block of the earlier model. Although it might at first glance be concluded that this part of the cowling should be very carefully designed for minimum drag and maximum flow, it is undoubtedly true that the presence of the propeller in the full-scale installation so changes conditions in this region that any conclusions thus obtained would be of doubtful validity. A few tests were made, however, to study the influence of varying nose-cap sizes and shapes, but when the difficulty of interpreting the results for application to full-scale design was considered, no definite conclusions could be reached. Comparable tests in flight indicated that the shape of this part of the cowl had little effect on either drag or cooling.

Fig. 6 presents the results of the series of flap-angle tests to show the influence of angle on airflow. The two curves were obtained with flaps of two different lengths. It is well indicated that angles greater than 40 deg. are of no use whatever and it is likely that the practical limit probably

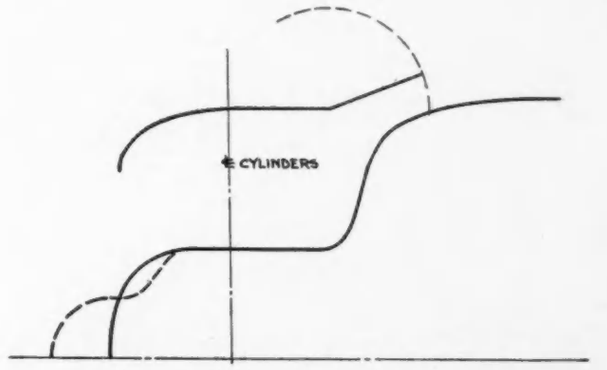


Fig. 4—Model Cowl Arrangement for Tests with a Large Range of Flap Angles

The broken line indicates the nose shape for the earlier series of tests.

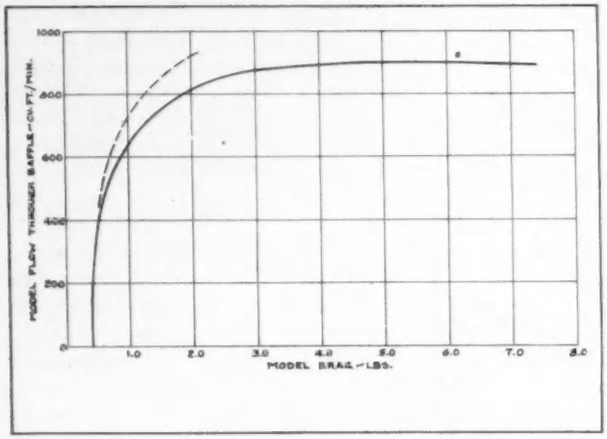


Fig. 5—Effect of Cowl Flaps on Flow and Drag
The broken line shows the results obtained in the earlier wind-tunnel tests.

could be placed within the range from 20 to 30 deg. It is interesting to note also that the long flaps do not give substantially higher flows at high angles than are obtained with those of shorter chord. For extremely short chords the flow at a given angle will naturally decrease, but it is apparent that the flaps need not be longer than the shorter of those represented in Fig. 6.

Firewall Flaps.—Considerable experience in the design of cowls for controlled cooling indicated that there would be many practical advantages in locating the flaps and their controlling mechanism fairly well back from the engine so that support could be obtained directly from the fuselage structure at the firewall. To investigate the advisability of this change from an aerodynamic point of view, wind-tunnel tests were conducted with a cowl incorporating flaps identical with those used in the tests just described, but with the flap hinge-point and nacelle shoulder moved well to the rear. Two of these rearward locations of flap and shoulder were tried, as is indicated in Fig. 7. That there is no important loss in efficiency was shown by the test results. A single drag-flow curve adequately represented the data for the two series of firewall flaps, and this curve was almost coincident with that

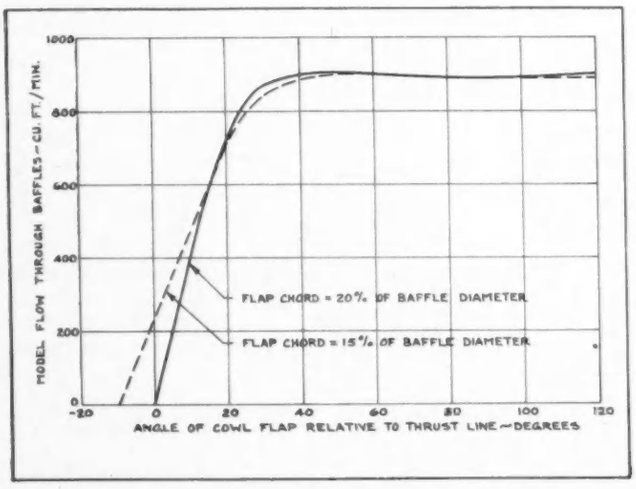


Fig. 6—Variation in Airflow Through a Model with Cowl-Flap Angle

for the cowl with forward hinge-location. The greatest discrepancy was a 3 per cent decrease in flow at high flap-angles.

Flight Tests

During the Spring of 1935, such a firewall-flap cowl was flight-tested on the Vought V-50 airplane powered with a Pratt & Whitney Twin-Wasp-Junior engine. The tests were made not only to determine the merits of the particular flapped-cowl arrangement but also to investigate the action of the flaps at angles greater than 20 deg., the maximum angle available with the controllable cowl described in the earlier paper.

The installation, which was designed by the Chance Vought Corp., included eleven interlocking flaps of 7½-in. chord (16.3 per cent of baffle diameter) hinged to the trailing edge of a long-skirted, N.A.C.A.-type ring-cowl and operable from the cockpit through an angular range of 55 deg. There was no wrapper or inner cowl between the engine and the firewall. The cooling-air-exit gill was formed by the rear edge

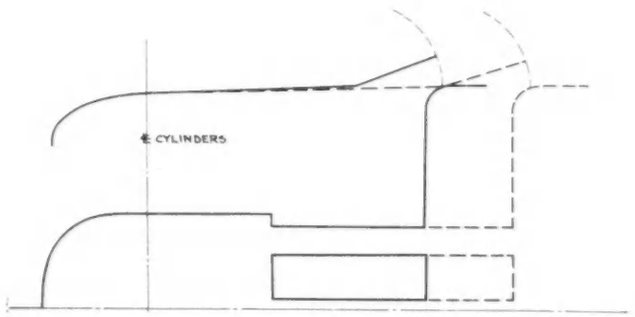


Fig. 7—Model Arrangement for Tests of Firewall Flaps
The solid and the broken lines indicate two relative locations of engine and firewall.

of the flaps and the firewall shoulder. Through the bottom 29 per cent of the cowl circumference, which was not provided with flaps because of installation difficulties, the cowl skirt extended back to the firewall, leaving practically no gill opening. The exhaust collector was placed inside the cowl and, to prevent it from heating the engine accessories, was contained in a light metal shroud through which cooling air was circulated.

In addition to the usual flight and engine instruments the airplane was equipped with 64 thermocouples placed to measure temperatures about the engine and with pressure fittings at 38 positions on the cowl for studies of the distribution of air loads. Means for the determination of the airflow through the baffles and a flow tank for measuring fuel consumption were also provided.

Fig. 10 shows the effects of flap angle on airplane speed, on the relative airflow past the baffles, and on cylinder temperatures in level flight at a constant-density altitude with constant engine power, engine speed, and specific fuel consumption. Such regulation of the test conditions was employed to eliminate from the data factors other than the influence of the flaps.

Because the airplane structure was designed for a Wasp engine, the power for these tests was limited to 615 b.hp., rather than the rated power of the engine. The results are in close agreement with the findings of the wind-tunnel tests

Fig. 8—Vought V-50 with Firewall Flaps at 20 Deg.

and the previous flight tests. The airplane speed was highest with the flaps at zero deg., the setting at which they best conformed to the general fuselage contour. Retraction of the flaps reduced the airflow through the cowl and increased cylinder temperatures with negligible change in airplane speed. Slight extensions of the flaps lowered the speed only slightly, but did produce a marked increase in flow with corresponding temperature reductions. Extending the flaps from 10 to 30 deg. resulted in further increase in flow and improvement in cooling, but at the expense of a decided loss of speed. Opening the flaps beyond 30 deg. reduced the speed still more with little or no cooling benefit; in fact, at angles beyond 40 deg. a tendency toward reduction of flow with an attendant temperature rise was apparent. It is of interest that the effects of flap position on average cylinder temperatures were representative of the effects on the temperatures of individual cylinders and, to a proportionate extent, on the temperatures of engine accessories.

The purpose of such a cowl is to control cooling by airflow regulation under the assumption that cooling is dependent on flow. The fulfillment of the purpose and the truth of the assumption are both apparent from these results. Increase of flap angle up to 40 deg. caused increases of flow in spite of reductions in airspeed. Examination of Fig. 10 bears evidence to the close dependency of cooling on airflow, a relationship which may be approximated by the equation:

$$\Delta T \alpha \left(\frac{1}{\rho Q}\right)^{y} \qquad (1)$$

where:

ΔT = Cylinder temperature minus cooling-air temperature
ρQ = Mass flow of cooling air

Although the value of the exponent y has been commonly estimated as slightly less than unity, these and other tests show its value to vary widely.

Fig. 11, showing the rate at which speed must be sacrificed for each progressive reduction of cylinder temperature, clearly pictures the advantages and the limitations of the cowl tested. At angles near zero deg., the flaps were highly efficient; at angles beyond 30 deg., they were obviously inefficient. At small angles, large variations in engine cooling may be produced with negligible changes in speed; but, at 30 deg., as shown by Fig. 11, an additional cylinder-head temperature reduction of 1 deg. fahr. would cost an added speed-loss of 1.5 m.p.h. Level-flight cooling-control would, in the case of this installation, appear to be valuable in the —10 to +10-deg. range, possible between 10 and 30, and inadvisable beyond 30 deg. In such a special case as the single-engine operation of a twin-engine airplane, the use of the full range of the cowl flaps offers a means of cooling the remaining engine in spite of the reduced airspeed, a factor of far greater importance than the slight additional loss in airplane performance due to the use of the flaps.

While the flight tests showed the use of the flaps in level flight to be of great advantage, their true function is cooling control in climb. It was for the improvement of cooling in climb that these flaps were devised, and it is under this condition that they most clearly demonstrate their worth. Climb tests were made at each of three flap-settings, holding the same appropriate airspeed in each case. A constant power, equal to that maintained for the level-flight runs, was held in climb to an altitude above that at which the cylinder temperatures peaked. The results obtained, given in Fig. 12, are consistent with the findings of the level-flight runs and of the previous flight tests. Opening the flaps from zero to 20 deg. caused the striking reduction in cylinder-head temperatures of 50 deg. fahr. and lowered the climb rate by a negligible amount, less than 3 per cent. Extending the flaps from 20 to 40 deg. lowered the cylinder-head temperatures 11 deg. fahr. more, but increased the accumulated climb-rate reduction to 11.4 per cent. Although in climb the added drag of the flaps is not a serious consideration, the level-flight results would indicate that even in climb the flaps should be limited to 30 deg. The marked advantages of the flaps in lowering climb temperatures are apparent and, because the flaps are adjustable, their use in climb involves no loss in level-flight performance.

The flight tests also included an investigation of the magnitudes and distribution of the air loads on the cowling at

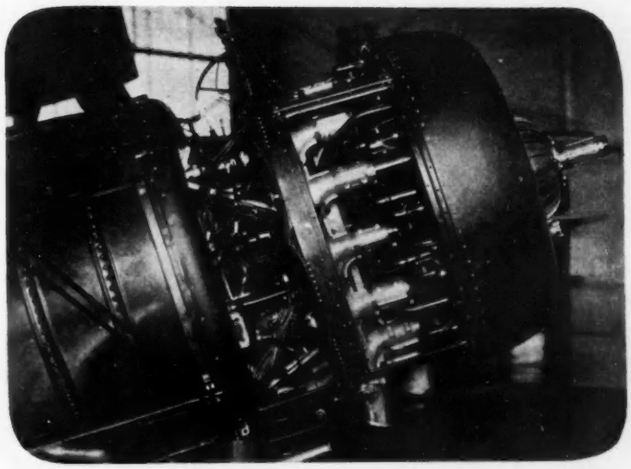


Fig. 9—Vought V-50 with Cowl Flaps Open and Side Panels Removed

various flap settings, the results of which are mentioned later in this paper.

This opportunity should be taken to warn that the flight tests revealed that serious tail buffeting was caused by excessive use of the flaps. At climbing airspeeds the disturbance was slight, even with the flaps extended 40 deg., but in level flight at 160 m.p.h. the use of the flaps at angles greater than 30 deg. was distinctly uncomfortable. Luckily, the worthwhile utilization of the flaps in level flight is restricted to small angular deflections. Under no circumstances should diving be attempted with the flaps extended. A placard to this effect or a spring in the operating mechanism which would allow the flaps to close at high airplane speeds should be a part of every installation of this type.

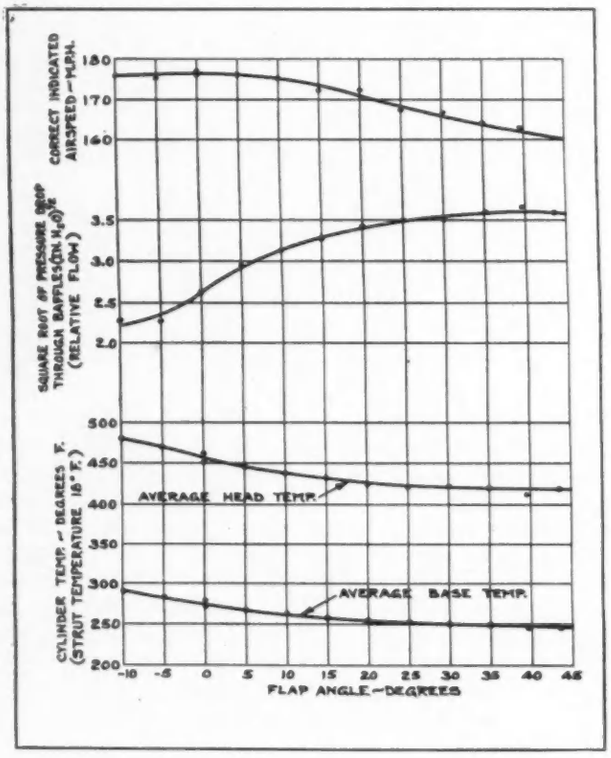

CORRECT INDICATED AIRSPEED—M.P.H.
SQUARE ROOT OF PRESSURE DROP THROUGH BAFFLES (IN. H2O) (RELATIVE FLOW)
CYLINDER TEMP.—DEGREES F. (STRUT TEMPERATURE 18° F.)
AVERAGE HEAD TEMP.
AVERAGE BASE TEMP.
FLAP ANGLE—DEGREES

Fig. 10—Results of Level-Flight Tests at 2000-Ft. Density Altitude with 615 b.hp.

Calculation of Cowl Performance

The foregoing information obtained in studying the performance of the flapped cowl supplements the earlier indications that, at least in qualitative relationships, the wind-tunnel results represent full-scale conditions. The model tests have shown the major questions to be considered in cowl design and have answered a great many general questions on design details, but even though actual drag and flow values were obtained in the tunnel, we have not yet shown to what extent the quantitative variations may be applied to full-scale cowls. There are many reasons why the model results are not directly applicable to performance calculations, but in spite of the limitations it is of interest to put the material in such a form as would facilitate the estimation of cowl characteristics.

The development of a general calculation method is simplified by conversion of the test data to absolute coefficient

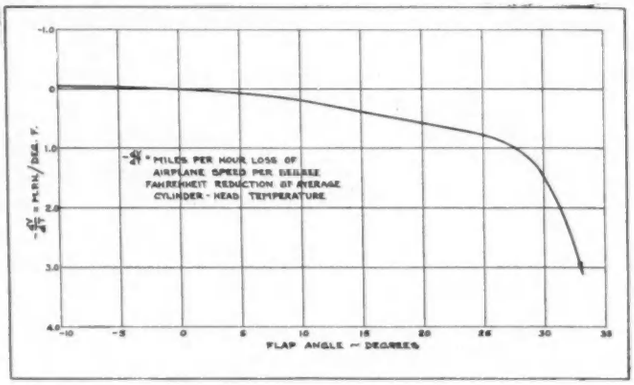

MILES PER HOUR LOSS OF AIRPLANE SPEED PER DEGREE FAHRENHEIT REDUCTION OF AVERAGE CYLINDER-HEAD TEMPERATURE
FLAP ANGLE — DEGREES

Fig. 11—Level-Flight-Speed Losses for Progressive Reductions in Cylinder Temperature

form. Three coefficients are required. The first of these is the usual absolute drag coefficient, which should be based on the cross-sectional area of the engine cowl at the center line of the engine cylinders. This coefficient has the form:

$$C_D = \frac{D}{\rho/2(V^2S)} \qquad (2)$$

To express the flow through the engine, we may use an equation of the following form:

$$Q = C_Q K_q S V \qquad (3)$$

where Q is the volume of air passing through the engine in unit time, and C_Q and K_q are non-dimensional coefficients. K_q can best be described as the orifice coefficient for the engine-baffle combination. It represents the ability of the engine disc to allow the passage of air under the influence of a given pressure drop. C_Q can then represent the tendency of the cowl arrangement to cause the flow of air. C_Q will depend mostly upon the shape of the cowling and the area of the exit gill, but it is not independent of K_q. A cowl of small exit area will exert a greater extracting effect when the obstruction due to the engine is great than it will when the obstruction is small. In the latter case the cowl skirt itself becomes an obstruction of major importance, while in the former case the small amount of air which passes through the engine will easily pass through the exit gill.

In view of the small changes in pressure through the baffle,

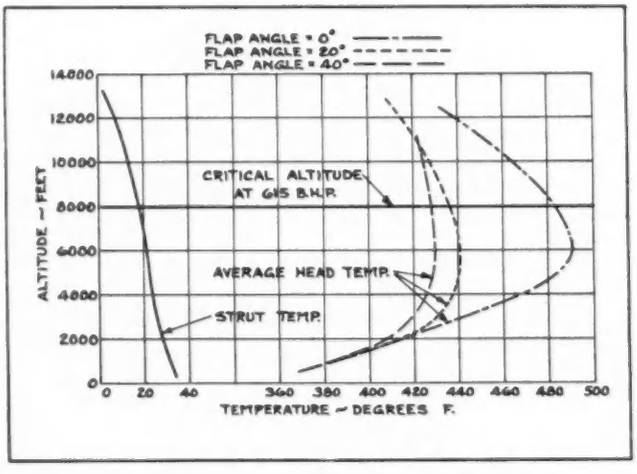


Fig. 12—Results of Climb Tests at 615 b.hp.

relative to the absolute atmospheric pressure, the flow of air may also be expressed approximately by the following formula:

$$Q = K_q\left(\frac{\Delta P}{q}\right)^{1/2} \cdot SV \qquad (4)$$

where ΔP is the pressure drop across the orifice and q is the dynamic pressure of the free airstream. Then

$$C_Q = \left(\frac{\Delta P}{q}\right)^{1/2} \qquad (5)$$

The foregoing formulas deal with volume flow of air, but with any given engine and baffle arrangement and at any one power output and cooling-air temperature, it is the mass flow of air which determines cooling. It is thus necessary in estimating the requirements for a proposed installation to make allowance for the altitude at which the airplane is to be flown. When the weight of air required is known, it may be divided by the density to yield a value of volume flow for the analysis.

It was mentioned previously that the orifice coefficient K_q affects the values of C_Q which will be obtained with any given cowl arrangement. The wind-tunnel tests were made for the

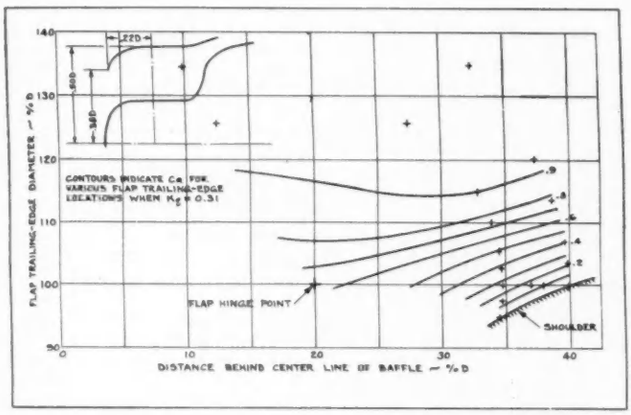

CONTOURS INDICATE Cq FOR VARIOUS FLAP TRAILING-EDGE LOCATIONS WHEN Kq = 0.31
FLAP HINGE POINT
SHOULDER
FLAP TRAILING-EDGE DIAMETER — % D
DISTANCE BEHIND CENTER LINE OF BAFFLE — % D

Fig. 13—Flow-Coefficient Contours for Complete Angle Range

most part with one size of baffle opening (which would correspond to one value of K_q), but sufficient points were obtained with other baffle constrictions so that the influence of K_q may be estimated. Thus it is possible to apply any of the data obtained at one K_q to calculations at other values by correcting the results in accordance with observed variations. Before any accurate estimates can be made for a full-scale cowl-design, it is necessary to know the value of K_q for the particular engine and inter-cylinder-baffle combination in question. The figures vary widely from one engine design to another, according to the proportions of the baffles (if any baffles are used) and to the number and size of the cylinders. Information on this subject can be obtained for any engine from tests on the ground. It is necessary to measure the flow of air through the baffles and the accompanying pressure drop, as these two factors, together with engine-disc area, determine K_q.

Before analyzing the wind-tunnel data in the form of values of C_Q for various cowls, it is necessary to point out the number of factors which must certainly affect the validity of the test results for application to full scale. The wind-tunnel test-points have not been corrected for the effects of horizontal buoyancy and tunnel obstruction, and they are of course subject to scale-effect errors. The Reynolds number for the model tests, using engine diameter as a reference length, was

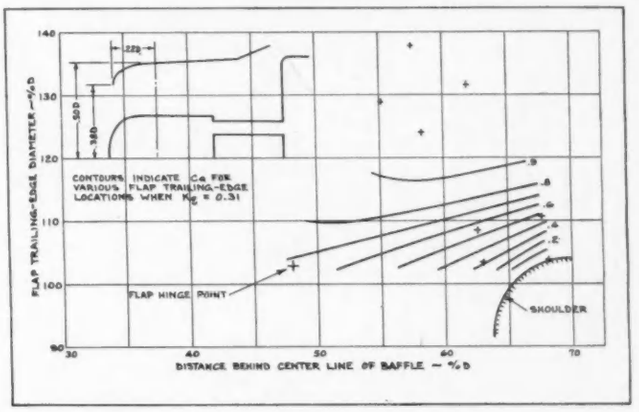

CONTOURS INDICATE Cq FOR VARIOUS FLAP TRAILING-EDGE LOCATIONS WHEN Kq = 0.31
FLAP HINGE POINT
SHOULDER
FLAP TRAILING-EDGE DIAMETER — % D
DISTANCE BEHIND CENTER LINE OF BAFFLE — % D

Fig. 14—Flow-Coefficient Contours for Firewall Flap Cowl

about 0.4×10^6, while for a normal full-scale case it would be 20 to 30 times greater. The wind-tunnel tests did not reproduce the effects of a propeller operating in front of the engine; neither did they involve heating of the air such as occurs in flight. The cowl designs for the tunnel were simplified; in actual installations there are the engine accessories and the exhaust system aft of the engine to change flow conditions. Moreover, since only a few general designs could be tested in this program, it is not likely that any of them will conform exactly to a particular full-scale case. Considerable caution is therefore necessary in estimating the effects of such differences as are known to exist.

But in spite of these discrepancies, which must inevitably lead to appreciable errors, a reduction of the wind-tunnel data to the form of performance charts should be of some value until an equally large body of similar material may be obtained from full-scale experience. Values of C_Q and K_q can be obtained from the model tests because measurements were made, not only of flow through the model, but also of the drop in pressure across the baffle. This drop in pressure, in combination with cowl area, tunnel speed, and volume flow, yields the values of K_q for the various baffle densities tested. It was found that for the cases with eighteen passages through the baffle open, K_q was about 0.31. This factor became as low as 0.10 when all but six of the openings through the baffle were closed. Because most of the data were obtained with a K_q of 0.31, this value will be assumed in presenting the

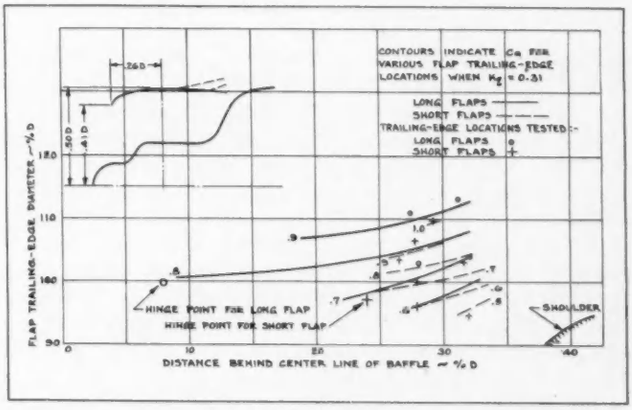

CONTOURS INDICATE Cq FOR VARIOUS FLAP TRAILING-EDGE LOCATIONS WHEN Kq = 0.31
LONG FLAPS
SHORT FLAPS
TRAILING-EDGE LOCATIONS TESTED:-
LONG FLAPS o
SHORT FLAPS +
HINGE POINT FOR LONG FLAP
HINGE POINT FOR SHORT FLAP
SHOULDER
FLAP TRAILING-EDGE DIAMETER — % D
DISTANCE BEHIND CENTER LINE OF BAFFLE — % D

Fig. 15—Flow-Coefficient Contours with Two Flap Hinge Locations

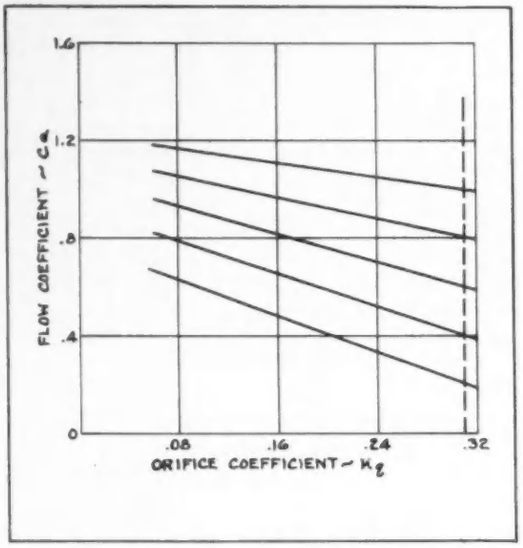


Fig. 16—Effect of Orifice Coefficient on Flow Coefficient with Constant Cowl Forms

curves of C_Q, but provision will be made for correction to other baffle densities.

The information on airflow has been organized in the form of three charts showing contours of constant C_Q for various cowl dimensions. The dimensions are expressed in percentage of cowl diameter, the most convenient unit of length. Fig. 13 shows these contours for the cowl which was tested with flap angles up to 120 deg. The particular trailing-edge locations which were investigated are indicated in Fig. 13. To obtain the flow coefficient C_Q for any cowl with proportions similar to this one, the location of the trailing edge at any flap angle and chord length is determined in relation to engine diameter. The point thus indicated in Fig. 13 gives the value of the coefficient. Although the coordinates of Fig. 13 are distance behind the center line of the baffle and flap trailing-edge diameter, the trailing-edge location relative to the nacelle or fuselage shoulder is the primary variable in determining the flow of air, and the shoulder should be taken as a datum in utilizing this and the following charts.

Fig. 14 shows similar contours for the firewall-flap model. The information is included for only one of the two relative spacings of the cowl shoulder and the baffle center-line. The curves for the other are practically identical when referred to distances from the shoulder.

Fig. 15 shows the effect of variation in flap-hinge location, as determined by the previous wind-tunnel tests. This variable was not included in the tests which yielded Figs. 13 and 14. In actual magnitude, as shown in Fig. 5, the flows obtained in these previous tests were somewhat higher than those of the present series. The discrepancy was due to the shape of the nose portion of the nacelle, but just which of the nose forms gave results comparable to those obtained in flight is not certain. Probably the form shown in Figs. 13 and 14 is the more truly representative, and it is therefore recommended that the values shown in Fig. 15 be reduced by about 15 per cent if used in estimating actual performance; see Fig. 5. The values on these three charts are simply a plot of the wind-tunnel results; whether they are truly applicable to full-scale cowls can be decided only after a greater fund of flight-test experience has been established.

The contour charts apply only for one value of the orifice coefficient: $K_q = 0.31$. Fig. 16 shows a series of guide lines relating C_Q and K_q. Each of these lines may be taken as representing some constant cowl-form. The value of C_Q at any desired K_q may be obtained by entering the figure at $K_q = 0.31$ with the value of C_Q obtained from one of the foregoing charts, following the guide lines to the required K_q and there reading the resulting value of C_Q. Fig. 16 is based on a fairing of the test points obtained with a number of cowl forms. The data were reasonably consistent and this chart should therefore give acceptable results.

When the value of the flow coefficient has been obtained from the chart which most nearly applies to the shape of the cowl in question and has been corrected to the proper value of the orifice coefficient, the volume flow through the engine may be calculated from Formula (3), relating C_Q with Q. It is then possible, knowing the air density, to estimate mass flow, the factor on which engine cooling depends.

Of secondary importance is the estimation of the drag to be expected with the flow just calculated. Fig. 17 shows the flow plotted for constant values of the orifice coefficient against the drag of the wind-tunnel model. The drag figures are for the model as tested; they include the drag chargeable to the nacelle. The chart is useful as an indication of the change in drag with change in flap angle, but it does not seem advisable to use these data for absolute values of drag. Fig. 17 is based on the results of the model tests of the firewall flaps and of the flaps shown in Fig. 13. These particular installations were, however, tested with only one value of the orifice coefficient, and the data at other values of K_q were therefore obtained by studying the variations which were shown by tests with the cowls of Fig. 15.

To illustrate the method of using the accompanying charts for the estimation of cowl performance, a sample calculation will be outlined. As a given condition of the problem we may take the cowl for the Vought V-50 airplane, an installation similar in general outline to the model of the firewall flaps. Its major characteristics are shown in Table 2.

By comparison with Fig. 14, it is seen that the shoulder of the model had a somewhat smaller relative radius. Because of this difference the conditions of the full-scale cowl are best represented if we assume, for application to the chart, that the trailing edge of the flap is located at a distance of about 57 per cent of the engine diameter behind the center line of the baffle. This location is determined by making the exit gap on the chart as nearly equivalent to the actual full-scale gap as is possible, taking into consideration the difference in shoulder shape. With the flap trailing-edge thus located, the flap hinge-point will be 16 per cent farther forward or at about the 41-per cent point. The method of choosing these various locations is not perfectly straightforward, and considerable judgment must be used in estimating the position of the given flap in terms of its probable effectiveness relative to the model flap. In this case, the hinge location does not correspond exactly to that of the model, but the effect of the difference is too small to justify correction for these approximate calculations.

Table 2—Cowl Dimensions in Percentage of Cowl Diameter at Engine Center-Line

Engine center-line to flap hinge	39
Flap chord	16
Flap trailing-edge to front face of firewall shoulder	6½
Radius of firewall shoulder	7½

Table 3—Sample Calculations of Flapped-Cowl Performance Values of C_Q

Flap Angle	From Fig. 14 ($K_q = 0.31$)	Corrected to ($K_q = 0.13$)	Corrected for Gap in Flaps	C_D	ΔC_D
−10	0.35	0.66	0.64	0.19	−0.05
0	0.49	0.78	0.75	0.24	0.00
10	0.68	0.91	0.87	0.32	0.08
20	0.84	1.02	0.97	0.42	0.18
30	0.90	1.06	1.01	0.50	0.26
40	0.91	1.07	1.02	0.52	0.28

The next step in the calculation is to determine the location on the chart of the flap trailing-edge with various flap angles. The values of C_Q (for a K_q of 0.31) may then be read. The second column of Table 3 shows the values we find for various flap angles.

It is necessary to correct C_Q to the proper value of K_q. Stand tests have been run on similar Twin Wasp Junior engines with pressure baffles, and from the results of these it would appear that the orifice coefficient for the present engine-baffle combination is about 0.13. This value will be used in these estimates. The third column of Table 3 contains the values of C_Q corrected to this K_q, a step accomplished with the aid of Fig. 16.

It was mentioned that the form of the cowl and flaps used on the V-50 airplane was similar in general proportions to the wind-tunnel model of the firewall flaps, but there was one important difference: the full-scale installation was equipped with flaps around only 71 per cent of its circumference. The remainder of the circumference was made up with the cowl skirt extending back almost to the firewall. Some sort of a correction is necessary in the calculations to allow for this difference. There are no complete data available on the effects of a gap in a trailing-edge flap, but it would appear from a study of several of the wind-tunnel models, such as the single-opening cowl and the four-door cowl already mentioned, that when the value of K_q is low, as it is in this case, the loss in C_Q for relatively small gaps in the flap is not great. When K_q is high, the loss becomes more serious. It was therefore assumed (more or less arbitrarily) that the 29-per cent gap caused a loss in C_Q of 5 per cent with the flaps open 40 deg. and that this loss decreased as the flaps were retracted. On this basis the fourth column of Table 3 was prepared.

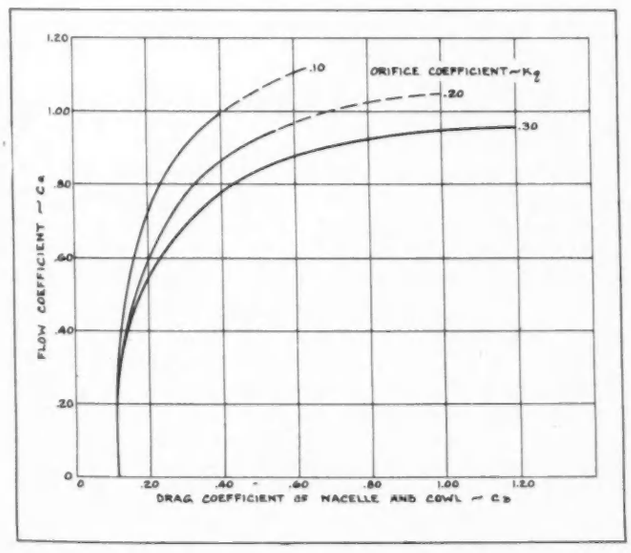


Fig. 17—Relation of Drag and Flow for Typical Cowls

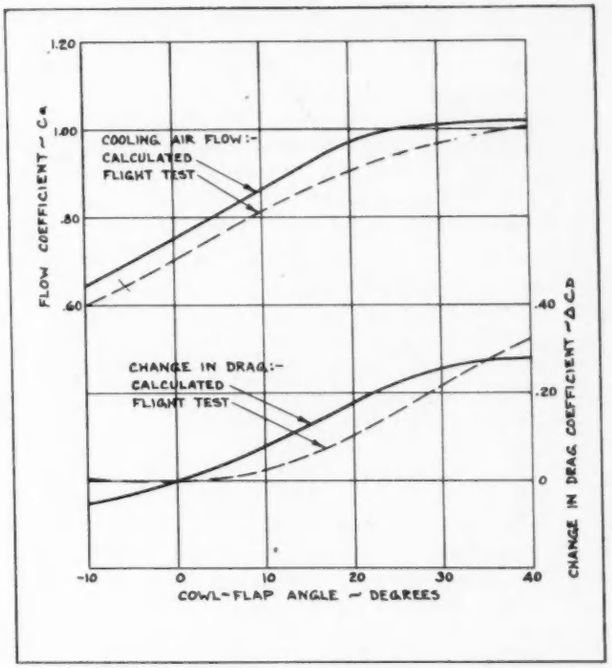


Fig. 18—Results of Sample Calculations of Cooling Airflow and Cowl Drag

Having the calculated values of C_Q, it should be possible to go directly to Fig. 17 and obtain corresponding values of C_D at the proper value of K_q, but in this case the 29 per cent gap in the cowl flaps should be the cause of some loss in efficiency. Adequate information on the magnitude of this effect is not available, but it probably is not large for a gap of this size, hence no correction will be applied. The fifth column of Table 3 is thus taken directly from Fig. 17. The last column shows the same data as drag-coefficient differences, the form to which the results should be reduced.

The solid lines of Fig. 18 show the plotted results of these drag and flow calculations. For comparison, the similar values from the flight tests are also included. It was possible to calculate the total airplane drag from the information in Fig. 10 and calculated propulsive efficiencies. The drags were converted to drag coefficients using cowl area as a basis. The values of the flow coefficient were obtained from the flight-test values of the pressure drop across the engine.

As incidental to the illustration, we may estimate, using the flight-test values of C_Q, the full-scale airflow for a K_q of 0.13. At zero-deg. flap-angle, C_Q equals 0.70 and the indicated airspeed equals 176.5 m.p.h. at 2000 ft. density altitude. The airflow was, then, 16,700 cu. ft. or 1210 lb. per min.

The agreement between the calculated and test results appears to be satisfactory in view of the approximate nature of the estimates. It is not to be expected that all such calculations will succeed as well, since in this case wind-tunnel tests had been run with a cowl which was quite similar to that used in flight. When less similarity exists, the estimates will be proportionately less accurate. The drag calculations show poorer agreement, but there is little reason to suppose that it should be much better.

It is evident that there are many problems still unsolved,

but until more information is available from flight tests with controllable cowls, the foregoing material should prove helpful in cowl design. The wind-tunnel tests have been and will continue to be invaluable for qualitative information, but accurate data for design purposes must evidently come from tests with full-scale cowls and actual engines operating under flight conditions.

Structural Design of Flapped Cowls

Loads.—The structural design of N.A.C.A. cowls has received relatively little attention. Various manufacturers have developed their own estimates of the possible loads, and revised them upward if something came adrift. The flight-test work of the United Aircraft Corp. has included pressure-distribution measurements over various types of cowling whenever such tests were convenient, and has accumulated considerable information on the loads imposed. Some of these tests were mentioned in the previous paper. Evaluation of the pressure-distribution results is somewhat laborious, and not all of the tests completed have been worked up. We hope to be able to present the digested data in a later paper.

For the present, we will show only some typical curves obtained from the firewall-flap installation on the V-50 airplane. Figs. 19 and 20 present the pressure over the outer and inner surfaces of the N.A.C.A. cowl for three angles of the cowl flap: zero, 20 and 40 deg. These pressures were measured by means of flush-type orifices set into the cowl, and connected to one side of a U-tube alcohol manometer. The other side of the manometer was connected to the static side of an airspeed head. Positive pressures are defined as those above free-air static pressure. The values are plotted normal to the cowl surface except at the flaps, where those for the 20 and 40-deg. settings are plotted normal to the zero-deg. position. The curves show that a change of flap angle has only a small effect on the pressures inside the cowl forward of the baffles, but produces a pronounced change at the other portions of the cowl. Increasing the flap opening displaces the pressure over the outside of the cowl in the positive direction, and those inside the cowl aft of the baffles in the negative direction. It is, of course, this latter change that increases the amount of cooling-air flow through the baffles when the cowl flaps are opened.

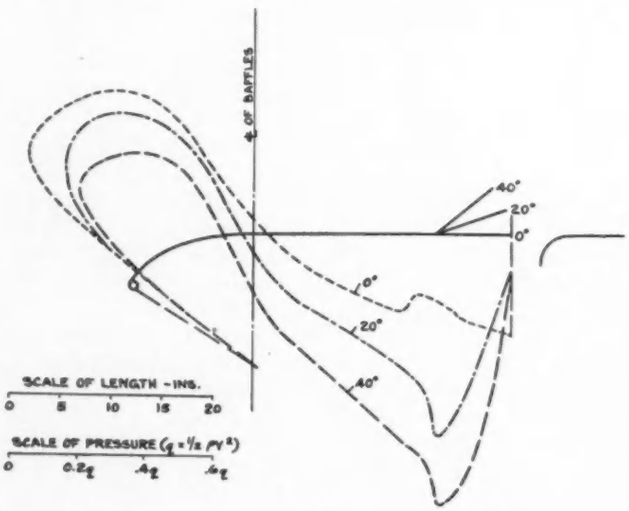


Fig. 19—Pressures on Outside of Cowl; Positive Pressure Plotted Downward

The critical portion of the cowl from the standpoint of structural loads is the curved nose-section forward of the pressure baffles. The low pressures over the outside, combined with the high pressure on the inside of this part of the cowl, produce a large resultant load tending to burst the nose section, and to move it forward into the propeller. The method of computing these loads, and the actual values for a number of typical cowls, will be presented in the later paper. We wish to point out, however, that the magnitude of these loads varies greatly with different cowl shapes, and that the local forces at points around the cowl circumference are affected by the angle between the cowl axis and the relative wind. A forward load of 680 lb. and 375-lb. hoop-tension were mentioned in the previous paper for a Hornet cowl of conventional design at 167 m.p.h. The loads on the present cowl were considerably smaller than these values, but by the same token another cowl shape might give higher forces. Cowls for military aircraft intended for diving operation may easily be subjected to loads of several thousand pounds; so, ample safety factors should be used in designing the cowl attachments.

The pressure-distribution curves show also that the loads on the cowl flaps in the open position reach respectable magnitudes. Since no previous information for designing the flaps and their operating mechanism have been published, the data from the V-50 tests have been worked up to give the hinge moments imposed. These results, given in Fig. 21, probably apply with reasonable accuracy to other flap chords and cowl shapes. The hinge moment-coefficient given in Fig. 21 as a function of flap angle is defined by the following equation:

$$M_H = K_H L C^2 \left(\frac{V_i}{100}\right)^2 \qquad (6)$$

where:

M_H = total hinge moment, lb-in.
L = length of hinge, in.
C = flap chord, in.
V_i = indicated airspeed, m.p.h.

To illustrate the application of this curve, let us compute the total hinge moment required to hold a set of cowl flaps of 8-in. chord on a circular cowl of 48-in. diameter at a flap angle of 30 deg. at 120 m.p.h. indicated airspeed. Fig. 21 gives the value of K_H at a flap angle of 30 deg. as 0.057. The total hinge moment is therefore

$$\text{Hinge Moment} = 0.057 \times 48\pi \times 8^2 \times \left(\frac{120}{100}\right)^2 = 795$$

If we assume that the flaps are driven through a lever 4 in. long, the resulting load in the control is about 200 lb. This force is somewhat greater than the pilot can exert through any simple system of levers; hence, the most satisfactory form of control mechanism has been found to consist of a screw arrangement operated by means of a crank located in the cockpit, similar to the control commonly employed for wing flaps.

Operating Mechanisms.—Numerous variations of this general method have been considered, including operation by an electric or hydraulic servomotor, either controlled by the pilot or arranged to adjust the flaps automatically to hold a predetermined cylinder temperature. A successful application using electric motors, controlled by switches in the cockpit, to drive the screw mechanism, has recently been completed on a twin-engine airplane. The weight, cost, and complication of this installation were considerably less than would have been required by a mechanical drive from the cockpit.

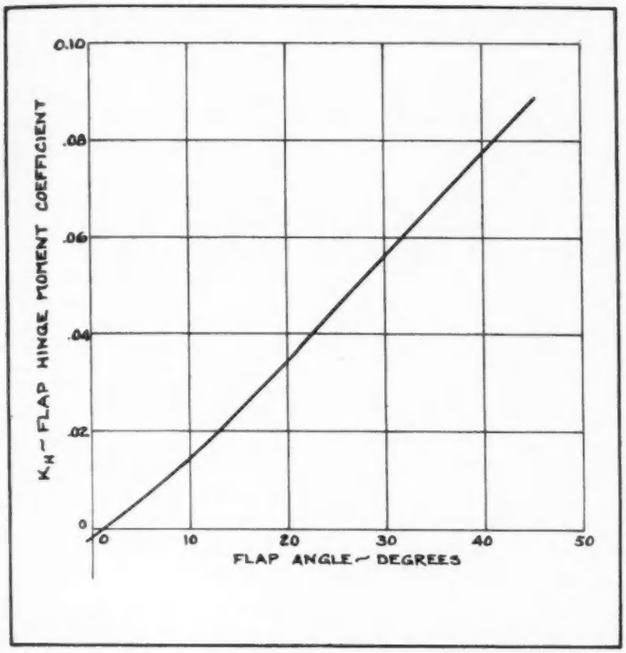


Fig. 21—Curve for Determining Cowl-Flap Hinge Moments

One of the most vexing problems in connection with the operation of the cowl flaps was that of devising a mechanism that would inter-connect the several flaps in such a manner that a control force applied to one of them would actuate the entire assembly without undue deflection or backlash. Most of the devices tried required ball-jointed linkages or flexible levers to accommodate the angular misalignment of adjacent flap hinges. None was entirely satisfactory, either because the mechanism required too much space in an already crowded accessory compartment, or because the drive was not sufficiently positive. As a result, most of the installations to date have had the flaps driven at several points by means of a group of flexible push-pull controls of the Arens or Simmonds type, driven at the cockpit end by means of a crank-operated screw and, in turn, driving alternate cowl flaps. The remaining flaps were connected to those driven by a sliding joint along their edges. This system worked well; but it was rather expensive and the task of finding an opening through the accessory compartment for each of the controls and a place for the necessary supports was somewhat difficult. A linkage for inter-connecting the flaps has recently been developed that seems to have solved the difficulties, and permits the flaps to be driven from one, or at the most, two points. The mechanism consists of a triangular member hinged to the flap supporting ring between adjacent flap hinges, and connected to a bearing on each of the flaps by means of a small link rod. The operation of the device depends upon the fact that the axes of the various pin joints intersect in common points on either side of the intermediate lever, resulting in a true linkage so that no ball joints or spring levers are required. The members and bearing areas are ample to withstand the loads imposed; hence, wear and backlash are reduced to a minimum. The parts are adaptable to any installation encountered so far, so that the cost of each installation is small. The weight of the assembly amounts to only 4.5 lb. for a cowl having 14 flaps.

Production Installations

The results of the researches described in this paper have been applied to several Chance Vought designs now being manufactured. The general arrangement is similar to that used on the V-50 airplane, but a number of improvements providing greater accessibility and simplified construction are incorporated.

The chief departure from previous practice is, of course, the elimination of the inner or wrapper cowl between the engine and the accessory compartment. The function of the wrapper cowl in a conventional installation is to provide a smooth shoulder for the cowl exit gill and to keep heated air from reaching the accessory space. Precautions are ordinarily taken to make the wrapper cowl as nearly airtight as possible to accomplish the second purpose. The V-50 flight-tests have shown, however, that the wrapper cowl may be safely omitted provided the exhaust collector is enclosed to prevent its heating the engine accessories. The resulting compartment tem-

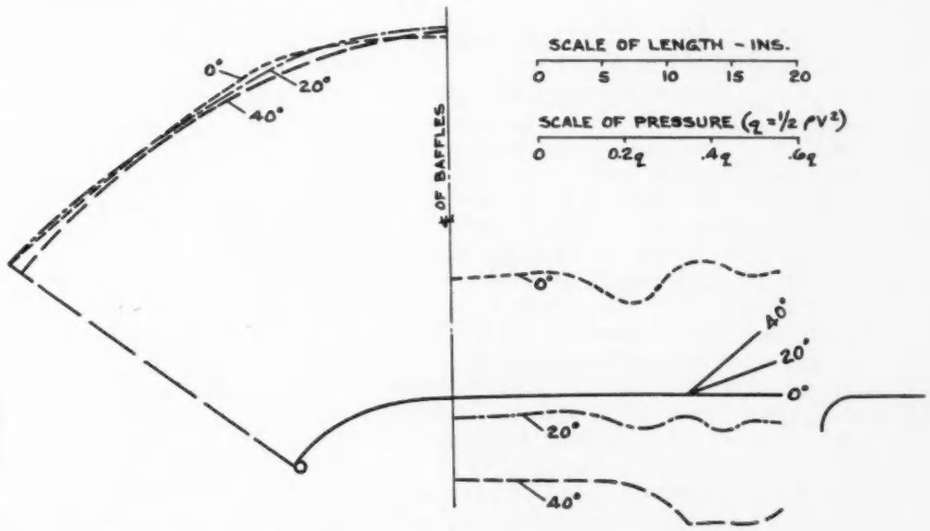


Fig. 20—Pressures on Inside of Cowl; Positive Pressure Plotted Upward

peratures are about the same as those obtained with the conventional arrangement.

The N.A.C.A. cowl consists of a fixed nose-piece, attached to the engine by means of fittings permitting radial expansion of the cylinders, and four skirt panels extending from this nose-piece to a channel mounted near the firewall, to which the cowl flaps are attached. Removal of these skirt panels provides practically unobstructed access to the engine and its accessories. The cowl flaps are interconnected and are operated by a single control, consisting of a screw arrangement controlled by a crank in the cockpit. The flaps may be released from the control unit and opened to the 90-deg. position to provide additional access to the powerplant.

The air ducts have, for the most part, been attached directly to the skirt panels, so that they are removed with the cowl. The shroud enclosing the exhaust collector, which is necessary to prevent overheating the accessory compartment, also serves as a convenient and ample source of preheated air for the carburetor. Provision is made for inducing a flow of air through the shroud to cool the collector when the carburetor is taking cold air.

Conclusion

Controllable cooling by means of the flapped cowl has proved its value on a wide variety of installations since it was first introduced a year and a half ago. The results of the experience thus accumulated, together with continued research and analysis of the data at hand, have solved most of the problems involved in its application. It is believed that many of the features of the installation just described will be useful to other designers. The modern high-output radial-engine crowds so much power into a small space, and requires so many accessories to perform all of the functions demanded of it, that the resulting congestion in the engine compartment threatens to overwhelm the designer and the service man alike. We have endeavored to show some of the means that may be employed to simplify their problems, in order to utilize the inherent advantage of this compact and efficient type of aircraft powerplant.

In conclusion, we wish to acknowledge the valuable cooperation of other members of the United Aircraft group, the assistance of the staff of the Aeronautical Engineering Department of the Massachusetts Institute of Technology which conducted the wind-tunnel tests, and the friendly encouragement of the United States Navy. Particular thanks are due to R. B. Beisel of the Chance Vought Corp., and to F. M. Thomas, formerly of the Research Division of the United Aircraft Corp., for their important contributions to the work reported in this paper.

Electric Cast-Iron

ELECTRIC cast-iron supplies engineers with a metal possessing strength considerably above that of even the best grade of gray iron or semi-steel formerly obtainable. It may be used extensively where ductility is not essential, but where strength, resiliency, and resistance to wear are desirable. It possesses a high degree of malleability; hence, it may be subjected to a considerable amount of shock loading. Electric iron is cheaper than its competitors, steel and malleable iron. It may be more readily cast, and constitutes a very useful addition to our ferrous casting-materials.

Although electric iron, unalloyed, is equal to most and superior to some alloyed irons, by reason of its inherent density and homogeneity of structure, its properties may be appreciably improved by the intelligent use of alloys. When judiciously applied, certain alloys used either singly or in combination do confer additional desirable properties on cast iron; however, this is predicated on the assumption that the base metal is of suitable composition to begin with. Alloys make a good iron better, but cannot make an evil iron good. Nickel, for instance, has contributed largely toward the advancement and improvement of gray iron in general, but cases without number have been observed where its indiscriminate use has failed to achieve the object sought. The same holds true for molybdenum, chromium and other commonly used alloys.

The full efficiency of these alloys cannot be realized unless the temperature of the metal is sufficiently high, not only to melt them, but to insure also their complete assimilation. Segregations or areas of highly concentrated alloys wreak havoc with machine tools and destroy the tenacity of the parent metal.

The outstanding characteristics of electric iron are:

(1) That it is a specification iron subject to close control both as to chemical and structural composition.

(2) It has fineness of grain-structure with uniformly dense fracture. This uniformity is noticeable particularly in castings of heavy cross-sections. Less variation in sectional hardness obtains than with other gray irons.

(3) Superheat employed in melting insures a fuller effectiveness of alloy additions.

(4) Its relative freedom from massive carbides and other non-metallic abrasives facilitates machining and provides for longer tool-life.

(5) Its higher strength—including transverse, tensile, compressive, shear and torsional—with increased toughness, resiliency and malleability, permit a very material lightening of section where ordinary gray iron has been used.

(6) The homogeneity of the metal lends itself to heat treatment whether it be to relieve casting stresses, to stabilize structure, for full annealing to facilitate machining, or for quenching and drawing to obtain increased hardness.

Because of these unusual properties, electric irons are being used to replace steel and malleable castings in many instances and to replace steel forgings in others.

Among typical applications for electric cast-iron may be listed, internal-combustion-engine cylinders, locomotive cylinders, brake shoes, brake drums, pistons, camshafts, crankshafts, valve tappets, hydraulic-pump castings, high-pressure valves, gears, refrigerator parts, radiator castings, air-conditioning parts, clutch and back plates, pressure plates, machinery exposed to heavy stresses, and chemical equipment subject to corrosion.

Excerpts from the paper on "Development of Electric Cast-Iron" presented at the May 1, 1935, Meeting of the Milwaukee Section by D. Porter Spencer, metallurgist, Belle City Malleable Iron Co.

Economics of Gasoline Volatility from the Refinery Viewpoint

By Hugh W. Field and Merrill J. Fowle
Atlantic Refining Co.

DURING the last decade there has been a steady trend toward more volatile gasolines. Lately, there has been offered to the public an extremely light motor fuel, the general production of which will markedly affect the refiner.

Motor fuel is generally a blend of "natural" or straight-run gasoline and cracked gasoline. Natural gasoline is considered as comprising that fuel obtained directly from the crude—casing-head, compression and crude naphtha — while cracked gasoline is produced by decomposition of the unusued portions of the crude.

Although there is at present an excess of casing-head gasoline which makes possible the production of these light fuels at low cost, a general production of them would mean that only that amount of light material recovered from the crude being handled would be available for blending to the lighter fuel. If the lighter fuel were made in this manner, it would ultimately cost the motorist 23 per cent more than the present type of gasoline. If this same gasoline were made by a cracking operation, it would necessitate a 35-per cent increase in the consumers' price.

Inasmuch as most refineries produce a gasoline that is a blend of these two materials, the ultimate increase in cost that must be borne by the consumer would amount to 29 per cent. These figures do not take into account the decrease in daily production of gasoline caused by the shift in volatility, and are, therefore, on the low side. However, it has been shown that the motorist ultimately will have to pay about 30 per cent more for whatever benefits he may obtain by the use of these very volatile gasolines.

SIX or eight years ago, the gasoline furnished to the motorist by practically all refiners had substantially the same volatility characteristics. Since that time, however, due to a variety of causes, there has been a definite trend toward the marketing of more volatile motor fuels. As a result, at present, there is little standardization of gasoline volatility except as regards the vapor-pressure limit imposed by the vapor-locking tendency of the fuel in the consumer's automobile.

This situation merits considerable analysis, particularly from the standpoint of the ultimate cost of operating a motor car using the more volatile fuels. It is the purpose of this paper to discuss the refinery economic picture of gasoline volatility, since the cost to the automobile owner must ultimately be affected by the refiner's cost.

Trend in Motor-Gasoline Volatility.—A brief discussion of the trend toward more volatile gasoline in recent years is presented to give a clarified view of the situation as it exists at present.

In Table 1, significant A.S.T.M. distillation points for four different ranges of gasoline of the summer type are given. These gasolines are arranged chronologically and grouped into the approximate period of their availability to the motorist. The trend is obvious and well defined.

For the purpose of this discussion, the 140-deg. fahr. point is taken as significant from the engine-starting angle, the 212-deg. fahr. point as a criterion of warming-up performance, and the 284-deg. fahr. point as important from the acceleration standpoint. Examining Table 1 from the performance viewpoint, the refiner has gradually and steadily improved his product in all three of these respects. The warming-up characteristic has received the greatest attention in order to obtain decreased use of the choke.

Until the development of the very volatile gasolines, no attempt has been made to remove the heavier components from the gasoline. It is not necessary to omit this fraction from gasoline, since these compounds cause no difficulty in operation with modern crankcase ventilation. The data presented in this paper will indicate that it is not only unnecessary to remove the heavy components but also undesirable, particularly from the economic standpoint.

The 1935 picture is quite different. Very wide ranges for

[This paper was presented at the Semi-Annual Meeting of the Society, White Sulphur Springs, West Va., June 20, 1935.]

Table 1—Volatilities of Typical Gasolines Arranged Chronologically

A. S. T. M. Distillation	Approximate Period			
Percentage Distilled at: Deg. Fahr.	1925 to 1929	1929 to 1933	1933 to 1934	Aviation Types 1935
140	3 - 5	7 - 10	11 - 13	13 - 16
212	17 - 20	28 - 31	33 - 37	40 - 51
284	50 - 53	52 - 56	61 - 66	70 - 92
374	83 - 88	83 - 88	90 - 94	.....
392	90 - 93	90 - 93	95 - 97	.....
End Point, Deg. F.	430 - 440	430 - 440	390 - 400	350 - 390

both 212 and 284-deg. fahr. points exist in the fuels available to the consumer. The 140-deg. fahr. point has not shifted materially, due to the vapor-pressure specification, but the remainder of the gasoline has been made much lighter and carried to considerable extremes in certain cases.

The warming-up and acceleration characteristics of these gasolines, while improved, are not at all standardized. The lack of standardization in acceleration potentialities of the gasoline is probably not serious, but the increased use of automatic chokes on the newer cars will demand some standardization of warming-up properties.

Production of More Volatile Gasoline.—In increasing the volatility of gasoline, two factors must be considered from the production standpoint; (*a*) the type of gasoline produced, and (*b*) the method of production. There are two general types of gasoline, "cracked" and straight-run or "natural."

In this paper, "natural" gasoline will be considered as coming from three sources. The products from these three sources generally carry the names "casinghead", "compression gasoline", and "crude naphtha". Casinghead, a light natural gasoline, is the material recovered from oil-well gas at the crude source. Compression gasoline, very similar in characteristics to casinghead, is obtained by compression of the gas evolved from the crude when distilled at the refinery. Crude naphtha is the gasoline distilled from the crude in the primary refinery distillation. For the purposes of simplification in the subsequent discussion, compression gasoline will be considered under the category of crude naphtha.

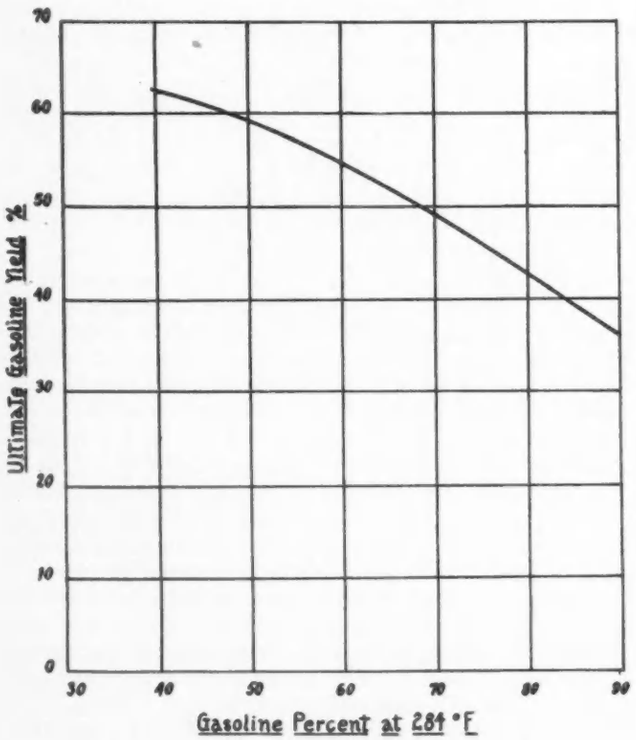


Fig. 1—Effect of Gasoline Volatility on the Ultimate Cracked-Gasoline Yield

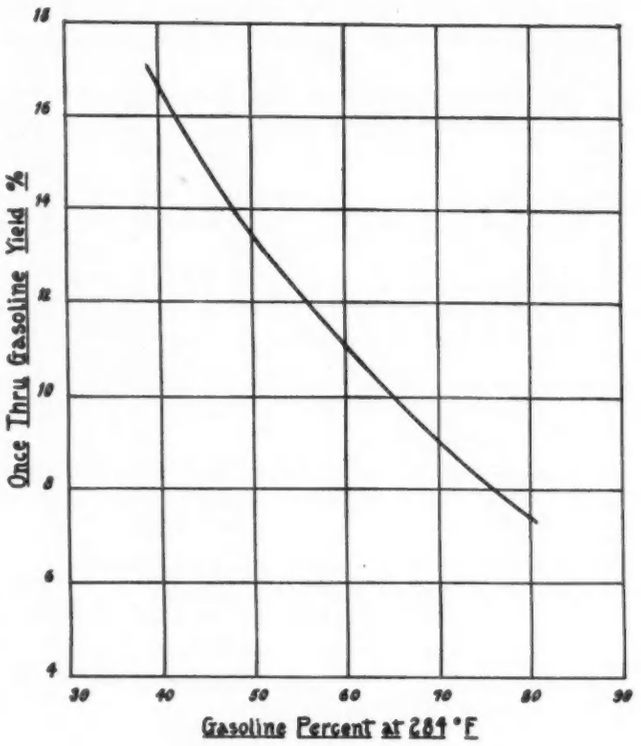


Fig. 2—Gasoline Volatility on a Once-Through Gasoline-Yield

Excess stocks of casinghead gasoline are in existence at present. From this it would seem at first glance that a shift to the lighter type of gasoline would be a healthy and economical move which would assist in working off the excess of this material. In fact, the lighter gasolines are now using casinghead. The amount of casinghead available is limited; that is, for each barrel of crude produced there is a maximum quantity of casinghead which can be recovered from the gas produced along with that barrel of crude.

Our discussion then should not confine itself to the present situation, which represents an unbalanced condition with regard to casinghead and crude, but should take in the broader aspects of the picture which would present themselves in the event of a general shift to very light gasoline. Under these conditions, the refiner would be forced to look in another direction for the light components of his gasoline.

In Table 2 are figures for an assumed typical crude from which finished straight-run gasoline of the 1934 type and the 1935 extremely light type are produced. This production covers the casinghead available from the crude source, as well as the crude naphtha and compression gasoline obtained in the primary refinery distillation.

Table 2—Yields on Primary Distillation of Crude

Type Gasoline	1934 Typical, Gal.	1935 Light, Gal.
Crude Charge	100	100
Crude Naphtha	35	20
Other Products	65	80
Casinghead Available	5	5
Total Gasoline	40	25

The production of lighter gasoline has caused a diversion of crude to products other than crude naphtha of 15 per cent of the crude charge. At present, this diversion to other products might well be considered as cracking stock. The economics of this picture will be taken up subsequently.

The percentage of cracked gasoline in the total has steadily increased until it is now well up to the 50-per cent mark. This type of gasoline therefore deserves careful consideration in our discussion. Further, if a decreased yield of crude naphtha is taken from the crude, as already shown, an increased load will be thrown on cracking to produce the light components necessary for light-gasoline production.

A set of curves is presented representing average cracking-still operation on typical charge, illustrating the effect on the production and yield when changing the volatility of the gasoline. In all these curves the common argument has been chosen as the A.S.T.M. per cent at 284 deg. fahr. It should be mentioned that, while these curves are for a given single charge to the still, other types of charge, while not giving the same absolute values, will exhibit the same relationship.

Fig. 1 shows the ultimate gasoline yield obtained from the fresh charge to the still. It can be seen that this yield decreases as the lighter gasoline is produced. This is due to the fact that, as lighter gasoline is produced, the material not removed from the still as gasoline is recycled for further cracking. This increases the production of gas and tar.

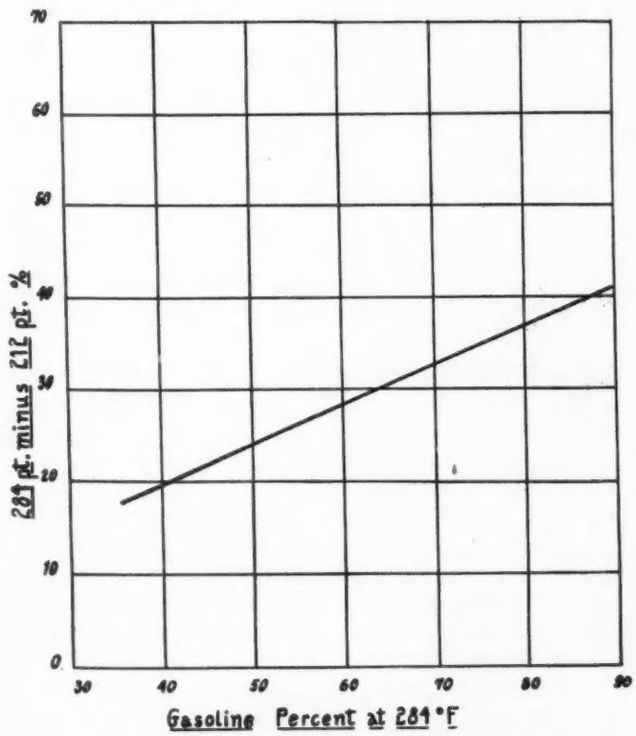


Fig. 3—Relation between the 212 and the 284-Deg. Fahr. Points

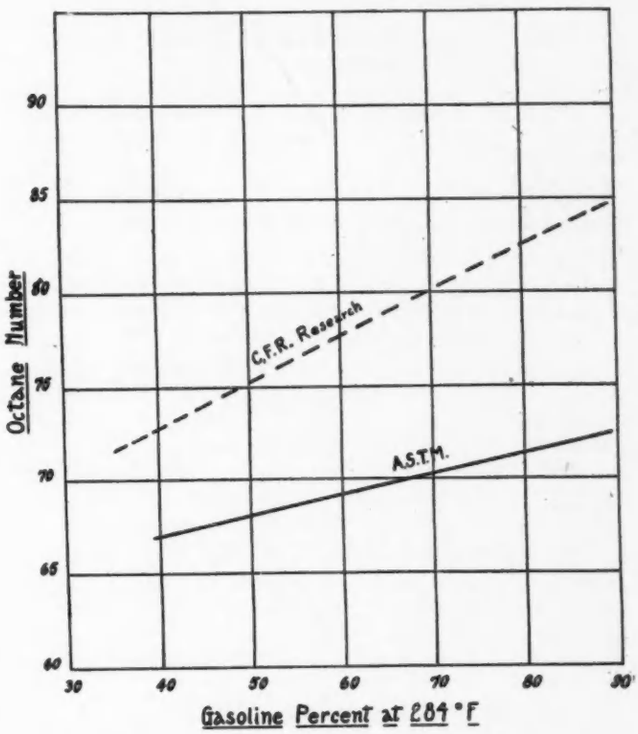


Fig. 4—Effect of Volatility on the Octane Numbers of Cracked Gasolines

Fig. 2 shows once-through yields of gasoline. This yield is the percentage of the recirculating oil passing through the cracking coil which is cracked to gasoline. For a given still, this recirculation is a constant quantity per day. Thus the once-through yield as plotted represents relative gasoline production per still operating-day. This curve falls sharply as the lighter gasolines are made. This is due to the fact that the material not removed as gasoline must be returned for further cracking. This oil is more difficult to crack than the fresh charge, resulting in a lower rate of cracking.

Fig. 3 presents the relationship which is obtained on the cracked gasoline between the 212 and 284-deg. fahr. points. This permits correlating these data with the previously discussed volatility trend.

Fig. 4 shows that, as the cracked gasolines are made more volatile, a gain in detonation value is obtained. This gain is not very marked over the ranges under discussion.

The individual-refinery situation determines whether the major portion of the burden of producing the more volatile gasoline would be taken by the crude stills or by the cracking stills. The average refinery would take the load on the cracking stills.

Cost of Increasing Gasoline Volatility.—We can calculate the cost of producing more-volatile gasolines from the data just presented. The figures will be strictly relative, due to the fact that different refinery situations create a difference in basic costs. Therefore, to make the picture as general as possible, the final economic answer in all cases is presented as a percentage increase in refinery cost for producing the extremely volatile gasolines.

Table 3 presents the operation of the primary refinery distil-

Table 3—Economics of "Natural" Gasoline Production

Type of Gasoline	1934 Typical	1935 Light
One Pipestill:		
Charge, 50-gal. bbls.	12,000	12,000
Gasoline, 50-gal. bbls.	4,200	2,400
Fuel and Cracking Stock, 50-gal. bbls.	7,800	9,600
Debits Per Day:		
Charge at $2.00 per 50-gal. bbl.	$24,000	$24,000
Casinghead at $3.50 per 50-gal. bbl.	2,100	2,100
Manufacturing Cost	500	500
Total Debits Per Day	$26,600	$26,600
Credits Per Day:		
Fuels and Cracking Stock at $1.50 per 50-gal. bbl.	$10,700	$14,400
Gasoline Cost:		
Per Day	$15,900	$12,200
Per Bbl.	3.31	$4.06
Per Gal.	6.62 (Cents)	8.12 (Cents)
Increased Cost, per cent	0	23

lation running to produce gasoline, which, when blended with the casinghead available, would meet the volatility specifications for the 1934 typical and the 1935 light gasoline. Here the point might be raised that, with present excesses of casinghead gasoline, a much higher percentage of this material can be used for producing the light type of gasoline. As previously pointed out, in this discussion, where the possibility of a general shift to light gasoline is being considered, a balanced casinghead-crude picture is assumed.

Table 4—Economics of Cracked-Gasoline Production

Case	1934 Typical	1935 Light
Percentage at 212 Deg. Fahr.	36	50
Percentage at 282 Deg. Fahr.	68	93
Throughput, 50-gal. bbls.	6,000	6,000
Once Through, per cent	9.4	5.5
Gasoline, 50-gal. bbls.	564	330
Ultimate, per cent	50.0	33.6
Charge, 50-gal. bbls. per day	1,128	982
Gasoline, 50-gal. bbls. per day	564	330
Fuels, 50-gal. bbls. per day	564	652
Debits Per Day:		
Charge at $1.75 per 50-gal. bbl.	$1,974	$1,718
Manufacturing Cost Per Day	250	250
Total Debits Per Day	$2,224	$1,968
Credits:		
Fuels at $1.00 per 50-gal. bbl.	$564	$652
Gasoline Cost:		
Per Day	$1,660	$1,316
Per Bbl. (50 gal.)	2.95	3.99
Per Gal.	5.90 (Cents)	7.98 (Cents)
Increased Cost, per cent	0	35

In this calculation it will be noted that the cost per gallon increases 1½ cents, or a 23-per cent increase in the refinery production-cost. This does not take into account the decrease in production of gasoline per still per day. In order for the refiner to maintain his required production, additional equipment investment would be required. This would be chargeable to the light gasoline. The 23 per cent then errs on the side of being low.

Table 4 presents a similar set of calculations on a cracking still running to gasoline of the two different volatilities. The charging stock to the cracking still in this case is gas oil obtained from the primary distillation of the crude. Here the increased cost of producing the lighter gasoline amounts to almost 2 cents per gal., or a 35-per cent increase in cost. This figure is also low, due to the reason previously mentioned.

Table 5—Summary Chart Combining "Natural" and Cracked Gasolines into a Composite Picture for the Whole Crude

Type of Gasoline	1934	1935
Crude Distillation: Charge, (50's)	12,000	12,000
Crude Naphtha, (50's)	4,200	2,400
Cracking Stock, (50's)	6,300	8,100
Fuels (Oil and Gas), (50's)	1,500	1,500
Casinghead Avails, 5 Per Cent Crude, (50's)	600	600
Total "Natural" Gasoline, (50's)	4,800	3,000
Cracking Stock: Charge, (50's)	6,300	8,100
Cracked Gasoline	3,150	2,723
Fuels (Oil and Gas)	3,150	5,377
Total: Distillation and Cracking, (50's)		
Crude Charge, (50's)	12,000	12,000
Casinghead, (50's)	600	600
Crude Naphtha, (50's)	4,200	2,400
Cracked Gasoline, (50's)	3,150	2,723
Total Gasoline, (50's)	$7,950	$5,723
Debits: Crude at $2.00	$24,000	$24,000
Manufacturing Cost,—Pipestill	500	500
—Cracking	1,386 (At 22 Cents)	2,025 (At 25 Cents)
Casinghead at $3.50	2,100	2,100
Total	$27,986	$28,625
Credit: Fuels at $1.00	4,650	6,877
Total Cost of Gasoline Produced	$23,336	$21,748
Gasoline Cost Per Gal.	5.88 (Cents)	7.58 (Cents)
Increased Cost, per cent	....	29

Since in most refineries gasoline is produced in both of the above ways, Table 5 was prepared to complete the picture. This is a summary chart combining "natural" and cracked gasoline into a composite picture for the whole crude. It shows that the total daily manufacturing costs for the two cases are approximately the same. This is reasonable, as we are assuming the same quantity of crude charged per day and operating approximately the same amount of refinery equipment. The amount of gasoline produced per day, however, is not the same. The increase in volatility reduces the gasoline

production. Therefore, the cost of gasoline per gallon has increased, the increase amounting to 29 per cent.

Summary

We have indicated the recent marked trend toward lighter gasolines which has resulted in a lack of uniformity in the motor fuels available to the public.

It is true that, at present, the most volatile gasolines are nearly all in the premium-price bracket, but there is a trend toward higher volatility in the standard-price range. Temporary excesses of light natural gasolines permit the production of volatile fuels at a low price. However, a general shift to highly volatile gasolines would soon consume these excesses, and result in an increased cost of roughly 20 per cent.

The more important picture to the average refiner is the production of cracked gasoline. Here a shift to lighter motor fuel will increase costs up to 35 per cent, in addition to requiring increased cracking capacity.

It has been shown that, unless some unforeseen development occurs, the motorist will ultimately have to pay about 30 per cent more for whatever benefits he may obtain from the use of a very volatile gasoline.

The authors are grateful to L. B. Smith and D. T. Shaw for assistance in the preparation of this paper.

Discussion

Automotive Designers Affected by Fuel-Volatility Situation

—Gilbert Way
Chrysler Corp.

THESE authors contend, and present data to show, that a continuation of the trend toward higher volatility is economically unsound and that a temporarily unbalanced condition exists which favors the production of light fuel.

The resulting lack in uniformity in the motor fuels available engenders difficulties in the way of carburetion, since, under identical conditions, widely differing treatment is required for the optimum utilization of fuels of widespread volatility.

The automotive designer, in endeavoring to fit his engine to the fuel, is placed in a quandary when from one source he is confronted with authentic data and trends urging him to design his engine to take full advantage of highly volatile fuels, while, on the other hand, equally reliable and convincing reports state the economics of the situation showing why these fuels may not continue to be produced.

Discussion of Fuel-Volatility-Symposium Papers

These discussions refer partly to the foregoing paper by H. W. Field and M. J. Fowle and partly to other papers presented at the Fuel-Volatility Symposium of the Semi-Annual Meeting of the Society, White Sulphur Springs, West Va., June 20, 1935. Other papers from this Symposium already printed in the S.A.E. JOURNAL *are: "Vapor-Lock Traits of Cars and Their Limitations on Gasoline Volatility", by Neil MacCoull and E. M. Barber, July, 1935, p. 237; "A Forgotten Property of Gasoline", by J. O. Eisinger and D. P. Barnard, August, 1935, p. 293; and "The Trends in Engine Design as Influenced by Fuel Volatility", by John M. Campbell, Wheeler G. Lovell and T. A. Boyd, August, 1935, p. 307.*

Warming-Up Quality as a Measure of Fuel Volatility

—T. B. Rendel
Shell Petroleum Corp.

THE "inferiority complex" which appears to prevent the volatility from assuming its recognized importance in gasoline specifications can be ascribed only to the difficulties involved in interpreting volatility data.

There is naturally a strong tendency to favor a product specification which involves only a single figure, over one which requires the mental balancing of two or more values. Thus, the fact that the weight of a gasoline is not a valid indication of its volatility did not hinder the retention of the gravity specification as a measure of quality in some states long after its lack of significance was first realized, and the greater convenience with which two gasolines can be compared on the basis of the single figure must be accepted as one of the chief reasons for this tendency.

To a certain extent the importance that is now placed on the antiknock value is also probably over-emphasized in comparison with the importance of volatility on performance for the same reasons though, unlike the gravity, the antiknock value does bear a valid relation to performance in an engine. However, the single tendency of a low-value fuel to detonate in a high-compression engine cannot be said to outweigh completely the importance of easy starting, quick warming-up, complete combustion, low oil-dilution, and low fuel-consumption, performance factors that are all directly influenced by the volatility of the gasoline, especially in cold weather.

It is also necessary, if automotive manufacturers are to design their cars to suit the fuels available and potentially available, for them to have a convenient single-figure yardstick to compare the effect of different design with gasolines of differing volatilities. There is thus felt to be a definite need for a single index of gasoline volatility which is a direct measure of the influence which the volatility exerts on engine performance, as established by actual tests.

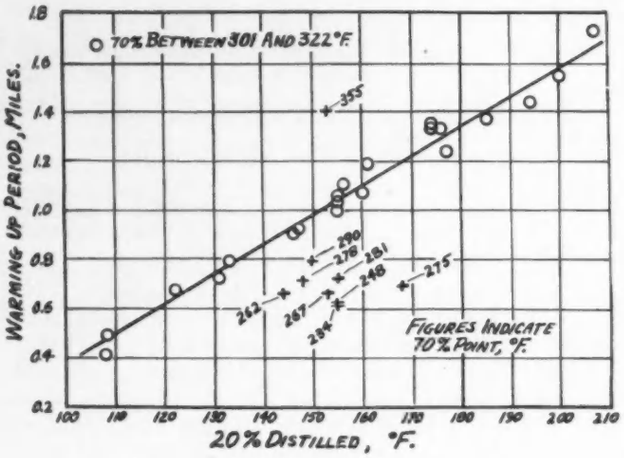


Fig. *A*—(Rendel Discussion) Influence of the 20-Per Cent Point on Warming-Up

Measurement of Performance

The establishment of such an index of performance, based on volatility, requires first an analysis of those measures of performance that are sensitive to volatility, to learn which factors need to be considered and what interrelations exist among them. The following brief outline covers the more significant of these factors, based on zero-weather operation: (*a*) starting, (*b*) warming-up period, and (*c*) warmed-up performance.

Starting Performance.—Ease of starting is, in a sense, the most important criterion of engine performance. It has been found, however, in numerous startability tests, that the effects of cranking speed and battery capacity at low temperatures are of major importance. Except in rare cases, it was generally found that any fuel which gave good warming-up performance caused no difficulty in starting. Thus, since the time required to warm up on a given fuel is a sufficiently important measure of performance so that it should be specified, a fuel which is sufficiently volatile to give quick warming-up is also sufficiently volatile to insure satisfactory starting in practice.

[a] See "The Construction of Graphical Charts", by John B. Peddle; McGraw-Hill Book Co., New York City.

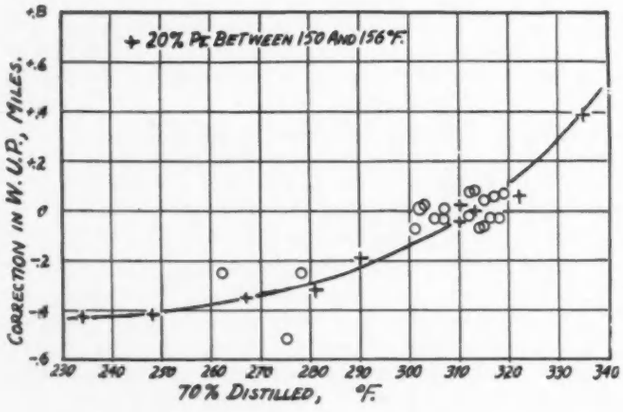


Fig. *B*—(Rendel Discussion) Correction to Be Made for Variation in the 70-Per Cent Point

Warming-Up.—In our work, the warming-up period was defined as the length of time required before a given load and speed could be maintained with the choke button fully pushed in. This was felt to be the criterion most significant to the general public and, furthermore, this criterion bears a close relation to the amount of fuel consumed in warming-up.

Up to this time tests have been made on 5 different makes of cars and about 36 different fuels, all tests being made on a chassis dynamometer in which it is possible to run at temperatures as low as —30 deg. fahr., the desired temperature being controlled automatically with a variation of approximately 4 deg. fahr.

Fig. *A* shows that the 20-per cent point definitely influences the warming-up period; however, the deviations from the curve are caused mainly by differences in the boiling points of the heavier fractions as indicated by the 70-per cent point of the distillation. Thus Fig. *A* must be supplemented by a correction curve such as that shown in Fig. *B*, showing the effect of the heavier fractions.

A simplified method of estimating the warming-up period

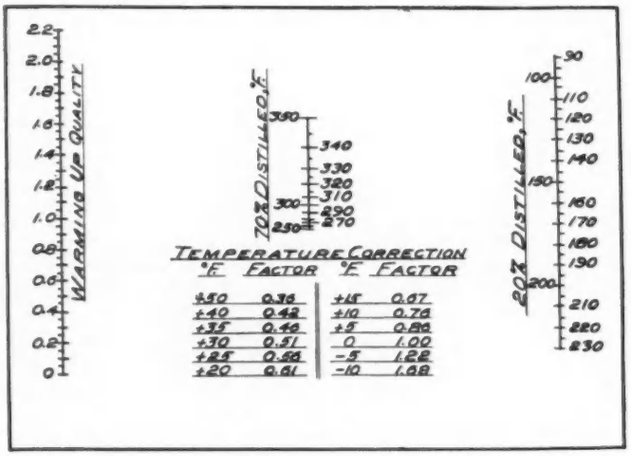


Fig. *C*—(Rendel Discussion) Alignment Chart for Calibrating Warming-Up Quality from the Distillation Curve

from the 20-per cent point, together with the appropriate correction for the 70-per cent point, is by the use of an alignment chart, which combines the relationships shown in Figs. *A* and *B*. Such a chart[a] is shown in Fig. *C* and, in this chart, the calculated warming-up period is given as a single figure for any gasoline.

The scale on the right-hand side of Fig. *C* is constructed proportional to the effect of the 20-per cent point, corrected for distillation loss obtained from Fig. *A*, while the scale in the middle is constructed proportional to the effect of the 70-per cent point corrected obtained from Fig. *B*. To obtain the warming-up volatility-index of a gasoline, these two distillation points are connected by a straight line which is extended to the scale on the left-hand side of the chart. With the use of this chart, it is now possible to bring out more clearly facts regarding the significance of factors that influence warming quality. These include such factors as atmospheric temperature, the automobile used, and driving conditions. These studies have also showed that the part-throttle fuel-economy in cold-weather driving is dependent upon the *warming-up*

quality, particularly where the latter is a measure of the amount of choking.

Effect of Atmospheric Temperature on Warming-Up Performance.—One of the outstanding factors found to influence the warming-up period was the test temperature. When the test was carried out at some temperature other than zero deg. fahr., the warming-up period differed from the calculated *warming-up quality* of the gasoline by a ratio which depended upon the temperature. Fig. *D* shows the effect of atmospheric temperature. From the shape of this curve it is seen that warming-up performance is influenced relatively little by atmospheric temperatures above zero deg. fahr.

Effect of Car Design on Warming-Up.—Characteristic factors for different cars can be obtained by a method similar to that used for obtaining the temperature factor, that is, by plotting the *warming-up quality* of the fuel (corrected for the test temperature from Fig. *D*) against the observed warming-up period, the slope of the line representing the car factor. Fig. *E* represents an illustration of the type of data obtained by so doing; a factor of 0.77 is found in this case.

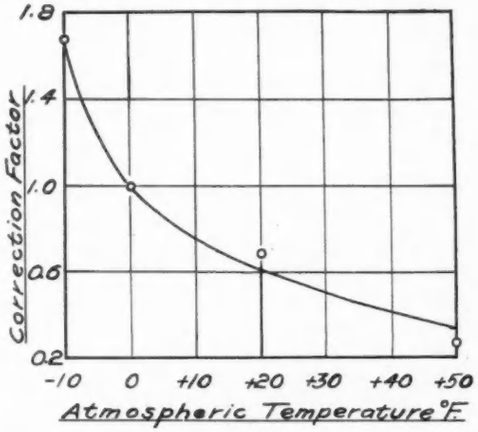


Fig. *D*—(Rendel Discussion) Effect of Atmospheric Temperature on the Warming-Up Period

Effect of Load.—Fig. *F* shows the results of warming-up tests to determine the effect of torque on the warming-up period. Inspection of these data shows that increasing the torque by 125 lb-ft. approximately doubles the distance required to warm up (that is, until no choke is required) at both 20 deg. fahr. and —10 deg. fahr. This increase in warming-up period is significant in that a fuel may be volatile enough to give almost instant warming-up when running at a steady speed of 20 m.p.h. on the level but requires an appreciably longer distance before quick accelerations can be attempted without the use of the choke.

In a similar manner the effect of speed was determined but the data obtained indicated that speed had little effect at 20 deg. fahr., though it was somewhat more effective at lower temperature.

Fuel Consumption

In the major portion of the investigation discussed so far the measure of engine performance used was the time required until a definite speed could be maintained with steady running without the use of the choke. This, of course, is only one of the several measures of performance and, to complete the picture of volatility index, fuel consumption must also be taken into account.

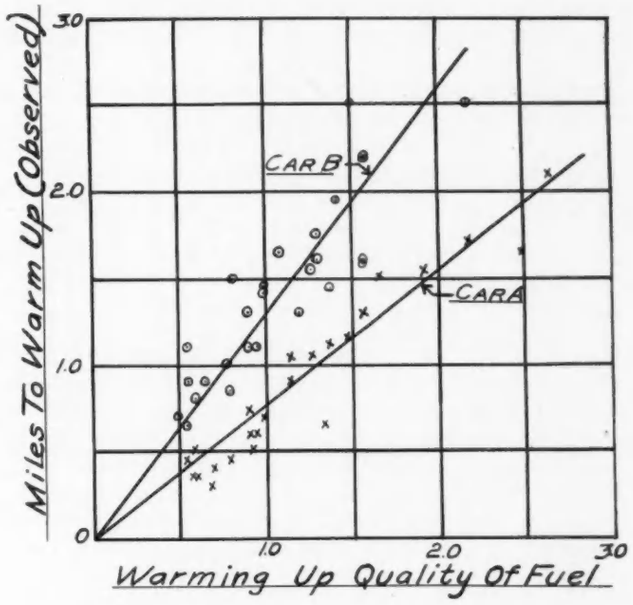


Fig. *E*—(Rendel Discussion) Influence of Car Design on the Warming-Up Period

The general type of data on fuel consumption obtained during a warming-up test is shown clearly in Fig. *G*. The effect of fuel volatility on the miles per gallon after the car has been run 5 min. is shown by the upper pair of lines in Fig. *H*, showing in both cases an advantage for the more volatile fuels. After the engine is fully warmed up, however, this advantage may be completely offset by the fact that in a warm engine the less volatile fuels, possibly because of their higher specific gravity, often give the best number of miles per gallon as is shown by the data on Car *B* in the lower pair of lines. That this did not happen in the case of Car *A* is possibly because this car was equipped with lean carbureter jets.

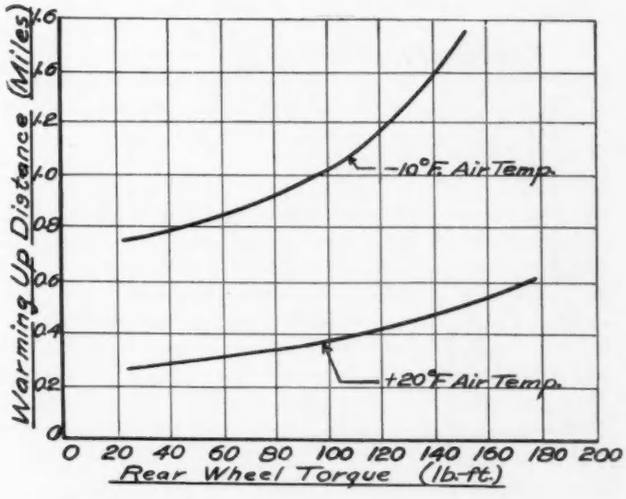


Fig. *F*—(Rendel Discussion) Effect of Load on Warming-Up Distance

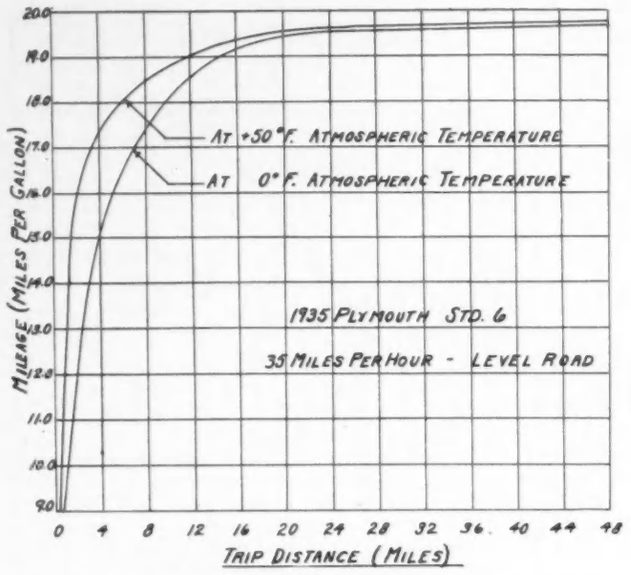

MILEAGE (MILES PER GALLON)
AT +50°F. ATMOSPHERIC TEMPERATURE
AT 0°F. ATMOSPHERIC TEMPERATURE
1935 PLYMOUTH STD. 6
35 MILES PER HOUR - LEVEL ROAD
TRIP DISTANCE (MILES)

Fig. G—(Rendel Discussion) Effect of Length of Trip on Miles Per Gallon

Instantaneous fuel consumptions in miles per gallon at various distances from the start

From these tests it appears that, in the majority of cars, the effect of the volatility of the fuel on the "warmed-up" mileage is very small and may be negative though, in some instances—as in Car *A*—maximum mileage is obtained at all times with the more-volatile fuel. The volatility index is, however, a significant measure of the part-throttle fuel-consumption during the first 5 or 10 min. of running.

In conclusion it may be said that, while the refiner knows a great deal about the boiling points of his gasoline because these are used in controlling his fractionating equipment, before these boiling-point data may be understood by a user of gasoline they must be interpreted in terms of the actual performance in which the user is interested.

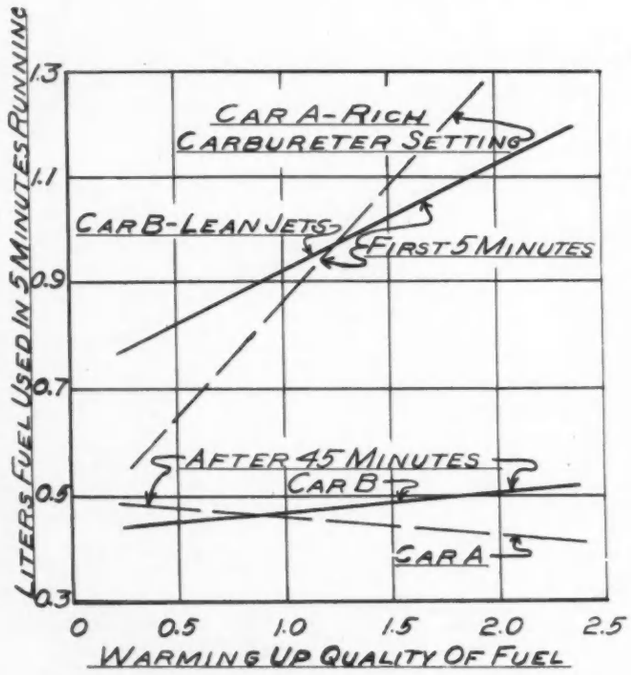


Fig. H—(Rendel Discussion) Influence of Warming-Up Quality on the Quantity of Fuel Consumed

It has been shown that the *warming-up quality* is a measure of fuel volatility whose units are made proportional to the actual performance of an automobile, rather than to the boiling point of the gasoline, and it is felt that the method used for interpretation of volatility data opens a way for further advancement of our knowledge of the relation of volatility to engine performance than was possible by direct comparison of test results.

Important Points Stated on Volatility Trends

—G. G. Oberfell
Phillips Petroleum Co.

THERE are a few important points in connection with this symposium on volatility trends of gasoline which I want to emphasize. First, I want to stress the fact that vapor pressure and volatility are not the same. You all know this, but it will do no harm to repeat it. Vapor lock is caused by high vapor pressure. Volatility has something to do with this difficulty, but not much. Widely divergent volatility causes trouble with automatic chokes. Vapor pressure has something to do with this difficulty, but not much. There is a reason in some instances for objecting to gasoline with an extremely high vapor pressure, but there are absolutely no grounds for finding fault with gasoline of extremely low vapor pressure and extremely high volatility.

One does not have to be an automotive or a petroleum engineer to interpret the data which have been presented. For several years, the vapor pressure and volatility have been increasing. This is an undisputed fact. Even if we knew nothing whatever of the changes which are going on in the technology of manufacturing gasoline, we would be compelled from the statistical data alone to conclude that this trend will continue. But there are other facts, which, even in the absence of these trends, would lead the well-informed technologist to predict increased volatility for gasolines in the future.

Now there is no use to deny certain facts. The petroleum industry cannot do anything to prevent these economic changes which are taking place. Neither can the automotive engineer have any appreciable effect upon these trends regardless of how the car is designed. The wise engineer will take these facts into consideration and act accordingly. Trying to place the blame upon each other will not help us. The handwriting is on the wall. If you design your car to handle today's gasolines only and do not provide some suitable means for the car to handle a gasoline of much higher volatility, which is bound to come within the next few years, your car owner is going to suffer great inconvenience.

You may ask us why these gasolines are going to become more volatile. The answer is, more cracking of oil and more and more conversion of the hydrocarbon gases to gasoline with low vapor pressure but high volatility. It has been customary in the past to ship natural gasoline to the refinery in order to tone down the natural-gasoline product with heavier gasoline made from crude oil. In recent years, in a few instances, the natural gasoline, freed from light gases,

has been shipped as a 100-per cent natural-gasoline product direct to the service station. Processes for cracking and converting the hydrocarbon gases into gasoline of high volatility and low vapor pressure will increase the tendency to ship directly to the filling stations gasolines which are made exclusively from gases. In these cases crude oil will not be used. There are going to be many of these instances of these highly volatile gasolines with exceptionally low vapor pressure within the lives of the new cars now being built. If the digestive system of these cars cannot assimilate cream as well as the skimmed milk, it is going to be the disposition of the car owner that sours and not the cream.

Now I want to make it plain that I am not criticizing the automotive engineer. He has done a good job. So has the petroleum technologist. The wave of increased volatility of gasoline that is upon us is not your fault. There is nothing which either you or we can do to stop it. Our problem is not to stop this progress but to shape our affairs in such a way as to ride along with it, not against it. What I have said about volatility of gasoline is not a threat, neither is it a prophecy. It is a promising statement of plain, pure and unadulterated facts.

Greater Control Of and Probably Higher Volatility Predicted

—G. H. Freyermuth
Standard Oil Co. (N. J.)

ANYONE reading the papers of the volatility session, and listening to the discussion following, might well wonder if this property of gasoline, as suggested by the title of the Barnard and Eisinger paper, should really be classified as "forgotten". As a matter of fact, the last few years have witnessed intensive activity in the further investigation of volatility effects, and both the experimental results cited in this session and the recent appearance of the several higher-than-normal volatile gasolines bear witness to the changing front in this regard.

Whatever else may be said regarding higher volatility, as one of the earliest marketers of an "aviation-type" automotive-gasoline we can unqualifiedly endorse two important aspects; (*a*) the motoring public clearly recognizes improved performance associated with higher volatility, and (*b*) satisfactory performance of such more-volatile gasolines necessitates much more rigid manufacturing control, particularly of the "front-end" volatility. Both of these have been brought out in the papers and discussion, and neither can be minimized.

The MacCoull and Barber paper is particularly timely in bringing once more to the attention of the automobile manufacturers the fact, obvious to any fuel marketer of today, that present-day fuel-systems still place a definite and serious limitation on the quality and economy of fuels available to the motoring public. No one can deny the splendid efforts made by many automobile manufacturers in fuel-system-temperature control, yet the fact remains that today we are but little better off than five years ago in permissible vapor pressures and light-end content of summer-grade fuels. In the long run, such a condition must become untenable, involving as it does the tremendous economic waste—which the fuel user ultimately must shoulder—both in discarding high-volatile high-antiknock-fuel fractions and in marketing costs in distributing two, three and sometimes even four seasonal grades of gasoline. It seems to us that if, as the car manufacturers claim, all possible has been accomplished in fuel-system-temperature control, then the time has come to consider radically different methods of transferring liquid fuel from the vehicle storage tank to the engine induction system.

Our studies indicate, in accordance with those of MacCoull and Barber, that idling, and operation after a short shutdown or idle—that is, a road stop or a traffic stop—are the most critical conditions to be met with in the newer fuel systems. In this respect, the newer cars seem to be getting "no better fast", thanks to the art departments in reducing ventilating facilities, to the body departments in appropriating for the passengers a generous portion of what was once considered necessary space for the engine, and to the engine designer himself in developing more and more power within continually smaller confines of space and material. We have heard much criticism of automobile design in following the traditions of the "horseless carriage"; has not tradition also played an important part in fuel-handling systems?

We are in full agreement that "vapor-lock" today assumes an importance surpassing its original significance. Perhaps a new word is in order, such as "vaporosity", to denote those conditions where large quantities of vapor are present, leaving "vapor-lock" to the ultimate conditions where actual cessation of fuel flow occurs. As MacCoull and Barber, as well as Dr. Bridgeman, have clearly shown, a single characteristic of the fuel no longer suffices to define its performance under elevated temperatures in fuel systems of the modern automobile. Some of the most serious vapor difficulties of today can occur with very-low-vapor-pressure fuels, once a sufficient temperature has been reached to initiate vaporization; conversely, high-vapor-pressure fuels of low front-end volatility may actually be quite free of "vapor-lock" difficulties in a system having reasonable vapor-handling capacity.

To insure satisfactory performance, the refiner today must specify both limiting vapor pressures and percentages evaporated at 140, 158 or even 176 deg. fahr. Not long ago propane was a by-word in fuel stabilization; then butane assumed the center of the stage; today we are also concerned with isobutane and the pentanes, so great has the care necessary in stabilization become. Any proposal to increase "volatility" by the addition of natural and stabilized natural gasoline cannot but be concerned with the limitations of front-end volatility, particularly with summer-grade fuels. This we believe to be a fundamental difficulty in attempting to define volatility characteristics by the percentage evaporated at any single temperature in the distillation range.

We believe greater control of and probably higher volatility will have a definite place in motor fuels of the future. The difficulties associated therewith are by no means insurmountable, and with continued cooperation of the automobile designer we look hopefully toward gradual elimination of present restrictions. Economic considerations are certainly of prime importance, yet if clear gains in performance are obtained a reasonable increase in cost may be justifiable. Moreover, it is not inconceivable that a further increase in octane-number requirements, involving additional cracking, and/or the development of gas-polymerization processes, may contribute to bringing volatility characteristics much more strongly into the fuel picture. This is a situation which both the engine builder and the fuel manufacturer must face in a thoroughly constructive manner if further progress is to be made.

Factors Controlling the Performance of Pistons and Piston-Rings

By D. D. Robertson
Chief Engineer, Wilkening Mfg. Co.

THIS paper points out how the problems of decreasing oil-consumption and blow-by and preventing piston-slap are affected by different piston and piston-ring characteristics, and some of the things that can be done toward solving them.

Improvements made in pistons—as to design, materials and construction—are cited. Problems concerning oil-control are stated, and means for solving them are set forth.

Interesting figures on piston-ring-wear tests are presented and the conclusion regarding them is that the wear of pistons, piston-rings and cylinders, is due almost entirely to factors which, though usually present, are outside influences.

These include abrasive material entering with the intake air, crankcase sludge, excessive choking, cold starting, and blow-by.

Wear inside the cylinders cannot be eliminated without the use of improved air-filters and oil-filters, and by improved cold-starting conditions.

NO parts of an engine are the subject of more research or of more difference of opinion than pistons and piston-rings. This is understandable in view of the requirements imposed upon them. The task of sealing gases under high pressures in the combustion chamber while moving up and down a none-too-straight cylinder at a wide range of speeds and temperatures can be equaled only by the task of returning to the crankcase the large amounts of oil continually being thrown into the cylinders by the crankshaft. Even though the pistons and rings may be performing perfectly, there may be some undetected factor causing high oil-consumption or blow-by for which they will be blamed.

Because of the complexity of factors such as inertia forces, effects of gas pressures, and temperatures and vibration periods, particularly at high speeds, preconceived theories, especially about piston-rings, are of little or no value. It is necessary to put the piston-rings into an engine, to go through the range of speeds and loads, and see what happens. Piston-ring theories must be developed afterward, and not before.

Many facts have been established and many improvements have been and are being made in decreasing oil-consumption and blow-by and in preventing piston-slap. It is the purpose of this paper to point out how these problems are affected by different piston and piston-ring characteristics and to call attention to some of the things that can be and are being done toward solving the problems.

Perhaps a better conception of the difficulty of the problems can be obtained by considering the fact that, in an eight-cylinder engine consuming 1 qt. of oil per 100 miles, a cubic 1/32 in. of oil is passing each piston at each stroke. This

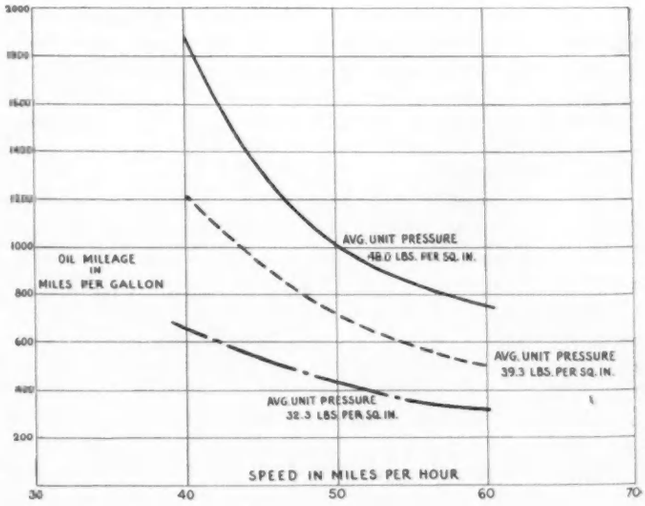

OIL MILEAGE IN MILES PER GALLON
AVG. UNIT PRESSURE 48.0 LBS. PER SQ. IN.
AVG. UNIT PRESSURE 39.3 LBS. PER SQ. IN.
AVG. UNIT PRESSURE 32.3 LBS. PER SQ. IN.
SPEED IN MILES PER HOUR
30
40
50
60
70

Fig. 1—Effect of Oil-Control-Ring Unit-Pressure on Oil-Mileage

[This paper was presented at the Meeting of the Philadelphia Section, May 8, 1935.]

amount of oil, spread out over the surface of the cylinder, makes a film of almost infinitesimal thickness which may be increased or decreased by the most minute details.

Much improvement has been made in pistons, in both alloy and cast-iron types. Both are now usually made elliptical or cam-ground. This permits fitting with a close clearance across the thrust faces, eliminating rocking and slapping of cold pistons. Piston-rocking pulls the faces of the rings from the wall, permitting blow-by and rapid wear of the ring edges.

The T-slot type of alloy piston appears to be a marked improvement over earlier types in which the slot extended the full length of the skirt, allowing the skirt to collapse under load and, after a period of service, to take a permanent collapse. The ability of the T-slot type to maintain the correct clearance has resulted in increased piston-life and in a marked decrease in oil-consumption.

An electro-chemical process called "alumiliting", which provides a film of aluminum oxide on the entire surface of the piston, has materially reduced wear of the skirt, ring-grooves and pin-hole. This film is very hard and at the same time porous, permitting the retention of oil at the surface.

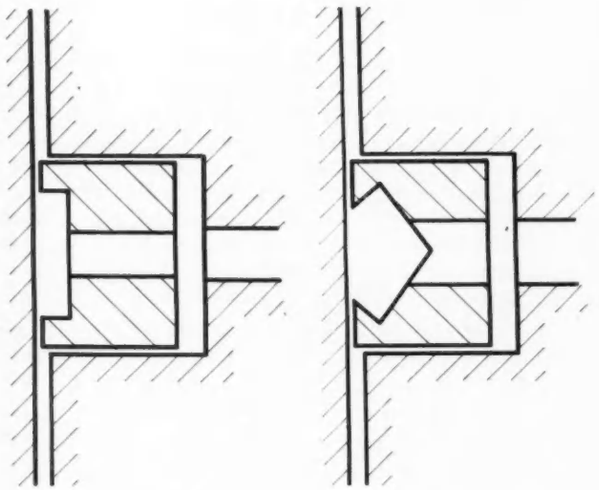


Fig. 2—Cross-Section of a "Wide-Channel" Oil-Control Ring

Fig. 3—Cross-Section of an Oil-Control Ring with Undercut Groove

The tin-plating of cast-iron pistons, now in almost universal use, has three definite advantages. The ability of the tin to flow under higher temperatures and pressures has greatly reduced the tendency to scuff and seize with close clearances. Some of the tin becomes transferred to the cylinder walls, materially reducing the rate of wear on the piston-rings and on the cylinders themselves. Carbon adheres less easily to the tinned surface of the pistons than to the cast iron.

The clearance of the pistons in the cylinders has a great effect on oil-consumption. In passenger-car engines, cam-ground cast-iron pistons are fitted with 0.0015-in. to 0.0025-in. clearance across the thrust faces. While with tin-plating the clearance may be reduced to 0.0003 in. without seizure, clearances of less than 0.0015 in. cause a marked increase in oil-consumption, apparently due to the increased distortion of pistons and cylinders from the increased frictional heat and to the lowering of the oil viscosity by the higher temperatures.

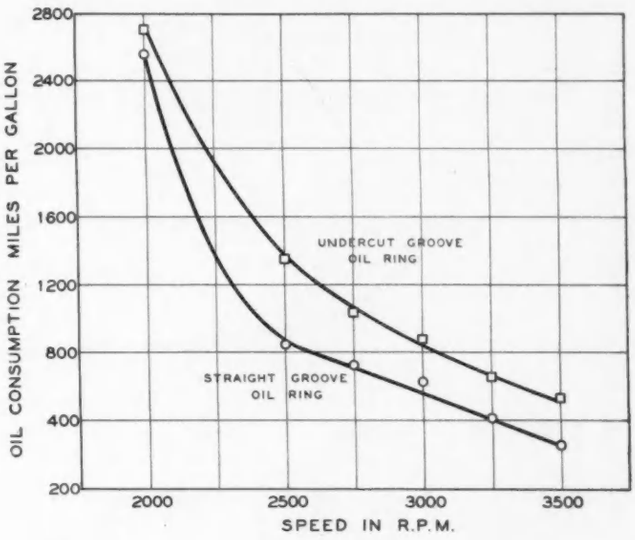


Fig. 4—Effect of the Shape of the Oil-Groove on Oil-Consumption

Between the 0.0015 in. and the 0.0025 in. necessary for manufacturing tolerances, there will be an increase in oil-consumption of 25 to 30 per cent. This is one of the factors causing the wide variation in oil-consumption between different cars of the same model. Initial clearances of 0.0028 in. and over will permit piston-rocking and rapid ring-wear in addition to increased oil-consumption. This is interesting in view of the fact that an initial clearance of 0.002 in. may grow to 0.0045 in. without rocking or piston-slap, due to the manner in which the cylinder and piston become worn-in together.

The diameter parallel with the piston-pin is usually from 0.005 in. to 0.008 in. less than the diameter across the thrust faces. More than 0.008-in. relief greatly increases oil-consumption. Less than 0.005 in. invites possible seizure.

Effect of Piston-Skirt Taper

Taper of the piston-skirt may affect oil-consumption greatly. If the diameter of the bottom of the skirt is 0.001 in. less than that at the top, oil-consumption may be increased 50 to 100 per cent. A taper in the reverse direction, that is, with the larger diameter at the bottom, has no appreciable effect.

T-slot alloy-pistons in passenger-car engines are preferably fitted to 0.001 to 0.002-in. clearance across the thrust diameter. Because of the greater coefficient of expansion, the relief along the piston-pin diameter is greater than with iron pistons, this diameter being preferably about 0.010 in. less than the thrust diameter. Increased clearances of these alloy pistons have the same effect on oil-consumption as with the iron pistons.

Clearances of pistons of larger diameters should, of course, be proportionately greater for both iron and alloy.

Side clearance of the piston-rings in the ring-grooves is very important. A minimum clearance of 0.0015 in. for the top ring and 0.001 in. for the other rings must be maintained to avoid the possibility of the rings' sticking in the grooves.

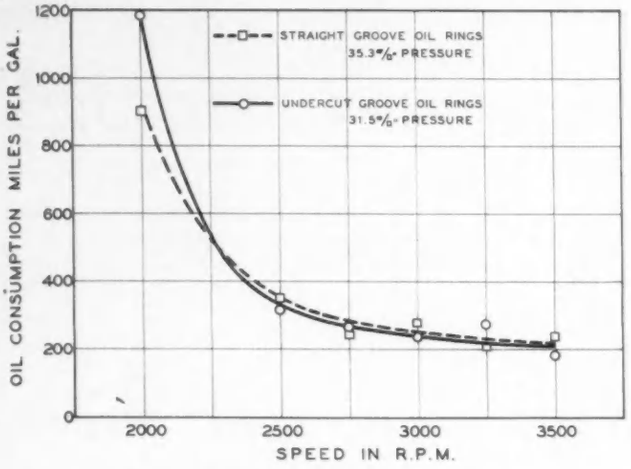


Fig. 5—Curves Illustrating That Equal Oil-Mileage Can Be Obtained with Less Unit-Pressure in the Undercut-Groove Ring

Compression-ring clearances should be kept as near this minimum as manufacturing tolerances permit, as blow-by increases rapidly with increased clearance. The clearance of oil-rings can be increased slightly without appreciable effect on oil-consumption. Some illustrations of the effect of side clearance of rings will be shown later.

It is essential that the ring-grooves be accurate and squarely at right angles with the axis of the piston and, of course, the piston itself must be correctly aligned with the crankshaft and the cylinders.

One of the principal causes of piston-slap and high oil-consumption with split-skirt alloy-pistons has been the increased piston-clearance from collapse of the piston-skirt. A large number of piston-expanders and piston-resizers are being used to correct this condition, thereby avoiding the expense of new pistons. Piston-expanders can be used with very successful results if they permit adjustment of the skirt diameter so that the correct clearance can be obtained, if they expand the skirt for its full length, and if they are resilient so as to prevent seizure. Some designs add too much weight to the pistons, and others have caused serious damage to pistons and cylinders. Therefore, in the selection, it is important to make sure that these requirements are met and that there is no possibility of damaging the engine.

Oil-Consumption a Problem

Getting satisfactory oil-consumption continues to be one of the biggest problems confronting engine builders. Practically all engines are being equipped with oil-control rings of the wide-channel type which depend very largely for their effectiveness upon a high unit-pressure against the cylinder wall. This permits them to cut through the oil-film, and prevents the oil from getting up past the piston.

The curves in Fig. 1 show the effect of different unit-pressures on oil-consumption. Tests were run consecutively in the same engine under the same conditions with rings of identical design, the only difference being the unit-pressure of the oil-rings. It would appear from this that the solution to the problem of high oil-consumption lies in continuing to increase the unit-pressure of the oil-rings. There are two definite reasons why this cannot be done at present. The first is that unit-pressures have already reached a maximum for the strength of the material at present available and, second, because of the alarming increase in the rate of wear of the oil-ring with an increase in pressure. As the rings wear, they open-up against the cylinder to take up the wear and thus lose in tension. This loss in tension causes a drop in unit-pressure, with the effect on oil-consumption indicated by these curves. The extent to which we have already gone in this direction is indicated by the rapid increase in the use of oil in most cars after a comparatively short period of mileage.

From the cross-section of a wide-channel type of oil-control ring in Fig. 2, it is easy to see these points. Because of the need to keep the total pressure of the ring as high as possible, the channel must be kept comparatively shallow and this limits its ability to store oil collected from the wall during the collecting part of the stroke. It therefore becomes essential that the leading scraping-edge do the brunt of the work, which is possible only when it is very narrow and when there is high pressure concentrated upon it. The effect of these narrow scraping-edges is to increase the rate of wear out of proportion to the increase in pressure because of the knife-edge action of such a narrow surface.

Undercut Grooves

A distinct improvement has been made in wide-channel rings by undercutting the groove as shown in Fig. 3. By making the channel in this shape it is possible to get more area for the storage of a larger amount of oil during the collecting part of the stroke while taking a minimum of the total pressure from the ring. This larger cross-section of the channel, together with the V-shaped scraping-edges which tend to lead the oil away from the wall and into the body of the channel, increases considerably the effectiveness of the ring as compared to a straight-groove ring of the same unit-pressure. This permits making wider lands on either side of the channel, getting away from the knife-edge action and greatly reducing the rate of wear.

The increased effectiveness of this undercut groove as compared with the straight-grooved ring of the same unit-pressure is indicated by the curves in Fig. 4, showing comparative oil-consumption results obtained in the same engine under the same conditions. Obviously, it is possible to get the same consumption with an appreciably lower unit-pressure in the

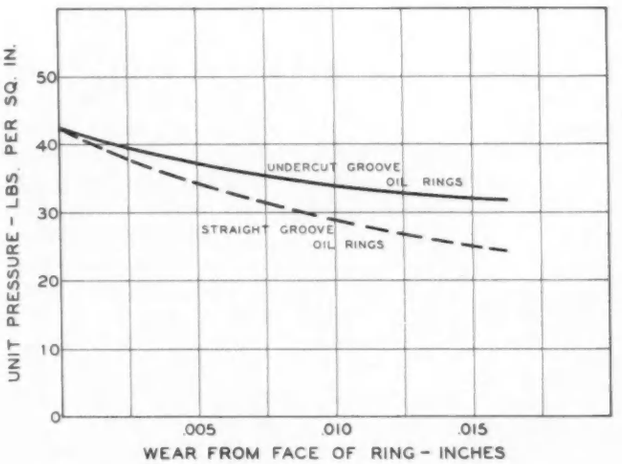


Fig. 6—Variation of Ring Wear with Unit-Pressure

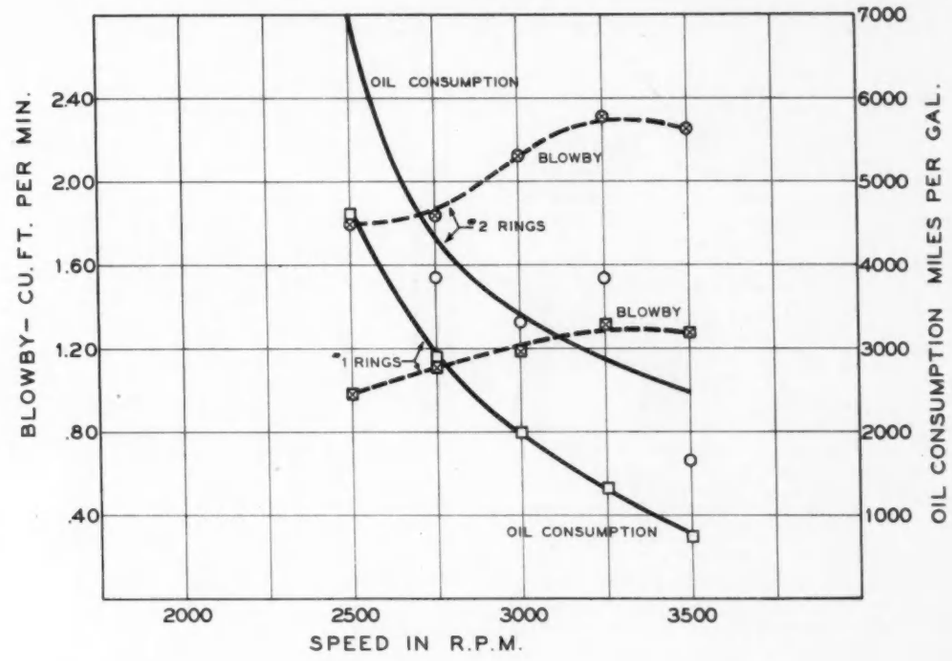


Fig. 7—Variation of Oil-Mileage and Blow-By with Speed, for Two Types of Rings

undercut-groove rings, as indicated in Fig. 5, in which identical results were obtained with oil-rings of the unit-pressures indicated.

In addition to the reduction in the rate of wear made possible by the use of lower unit-pressure and by the wider lands, there is the additional advantage in the undercut design that, as the face of the ring wears, the lands on either side of the channel become narrower. Thus the area in contact with the cylinders is reduced at the same time the pressure is decreased by the opening-up of the ring to take up the wear. This effect is indicated in Fig. 6, in which the unit-pressure is plotted against the wear from the face of the ring. Starting with the same initial pressure of 42 lb. per sq. in., the unit-pressure of the straight-groove ring would drop off to 25 lb. per sq. in. after 0.015 in. of wear from the face of the ring, whereas the unit-pressure of the undercut ring would be 32 lb. per sq. in. In addition to the slower rate of the wear, the effect of the wear is considerably diminished, so far as oil-consumption is concerned, as this is so dependent upon the unit-pressure.

Use of Drilled Holes

Another marked tendency in oil-control rings is the increased use of drilled holes rather than slots as a means of providing drainage through the rings. Even with the greatest care, it is impossible entirely to eliminate distortion both circumferentially and axially in milling slots of sufficient width to provide adequate drainage. The drilling of a series of holes can be accomplished without this distortion and, therefore, without this damage to the accuracy of the rings.

This is not, however, the principal advantage of the drilled holes as compared with the slots. The principal advantage lies in the lesser tendency to become clogged with carbon, and it is this fact that has caused a very rapid adoption of the drilled holes during the last two or three years. Reports from one of the largest engine manufacturers, by whom both types have been used for the last three years, indicate that the average mileage before clogging of drilled rings is 30,000 miles as against only 20,000 miles for the slotted type. As clogging of the oil-rings is one of the principal reasons for the rapid increase in oil-consumption, this feature of the drilled design is a substantial advantage.

In considering ways and means of controlling oil with piston-rings, one factor must always be kept in mind; that is, blow-by. Improvement in oil-consumption almost always is accompanied by a proportionate increase in blow-by, and vice

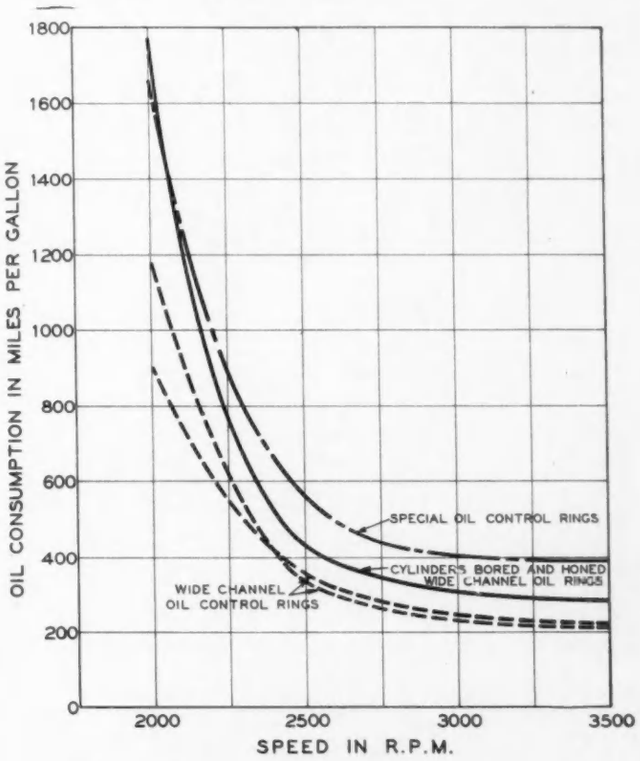


Fig. 8—Effects of Different Ring-Equipments on Oil-Mileage

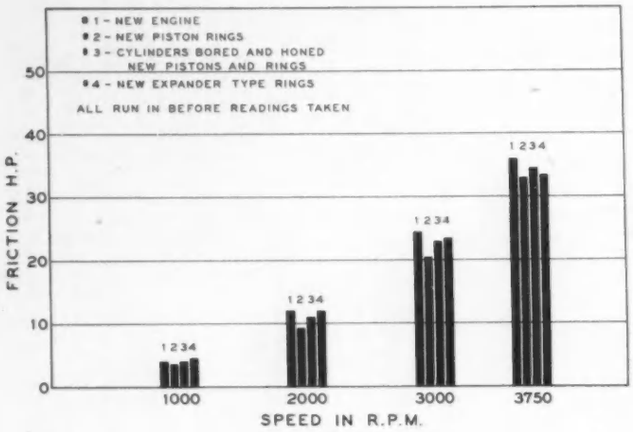


Fig. 9—Effects of Different Piston and Ring-Equipments on Friction Horsepower

versa. By the simple expedient of overlooking the blow-by, it is possible to get most remarkable results in controlling oil. This is the fact that the vast majority of piston-ring inventors seems to overlook. The curves in Fig. 7 indicate what may be accomplished by the very popular blow-by method of controlling oil. The lower curves for oil-consumption and blow-by were obtained with rings of conventional design. The upper curves were obtained with the same oil-rings by substituting compression-rings of a special design which had wonderful possibilities on paper. The improvement in consumption seems almost too good to be true until we look at the blow-by curves and see that we have increased the blow-by in almost the same relation that we have improved the oil control and, in so doing, created a condition of real danger of considerable damage to the engine, in addition to pouring forth large quantities of obnoxious fumes.

Blow-by is an important factor in controlling oil and, within certain limits, is not dangerous or objectionable. Within these limits it can be and is used to considerable advantage. It is a factor that can never be overlooked.

These tests also indicate the considerable effect on oil-consumption of the compression-rings and the fact that the oil-control rings themselves are not the sole factor in the

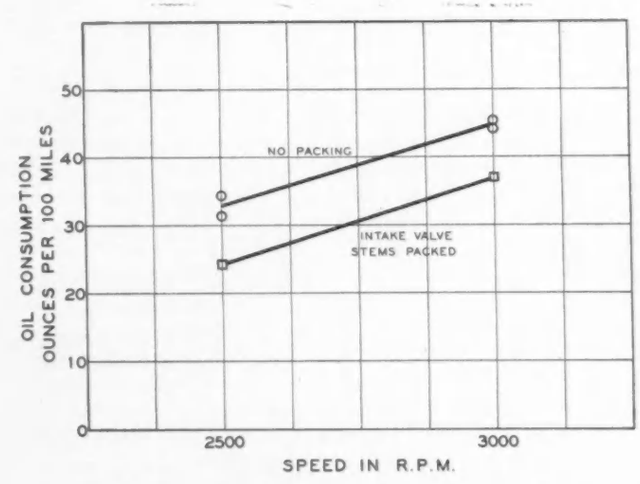


Fig. 10—Effect of Leakage Through Inlet-Valve Guides on Oil-Consumption

ability of the piston-ring assembly to control oil. They also indicate most clearly that no real contribution to piston-ring design can be made unless it improves oil-control without increasing the blow-by or reduces the blow-by without increasing the oil-consumption.

While oil-control continues to be a major problem with engine builders, it is even more of a problem to the many thousands attempting to correct oil pumping in cars already turned loose on the general public. The worn cylinders, the increased piston-clearance, and the worn ring-grooves of these engines present far more of a problem than do the new engines. True, it is possible to remachine the cylinders and install new pistons and restore the original conditions, but this is an expensive operation and one which frequently cannot be justified by the conditions of wear. However slight this wear may be, merely replacing the piston-rings will not, in the majority of cases, prove satisfactory. For many years

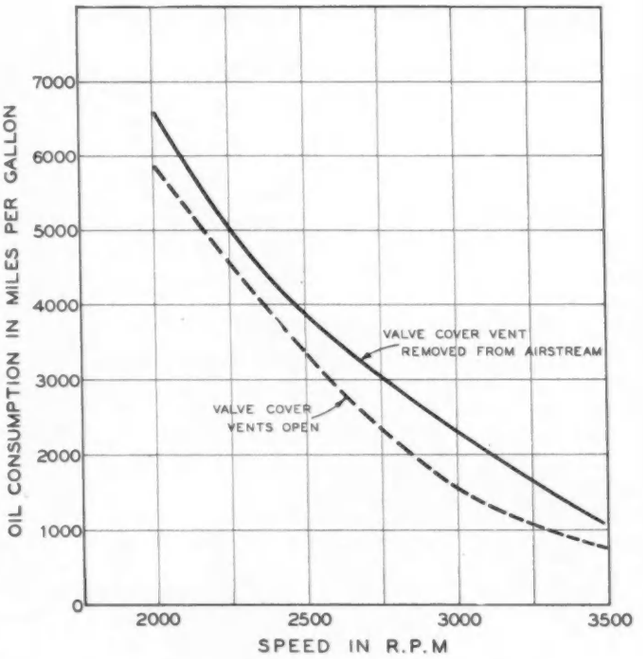


Fig. 11—Oil Loss Through Valve-Cover Vents

a wide variety of piston-ring designs have been sold to accommodate these worn cylinders and pistons, the designs usually including the use of a sinuous steel expander behind the cast-iron rings. The merit of some of these designs has been definitely established and, in spite of the great resistance they have had to overcome, they are coming more and more into use in the service field. In fact, the reboring of cylinders in passenger-car engines is rapidly becoming limited to those cylinders which are scored or otherwise damaged, while in commercial engines at least one or two sets of these rings precede a complete overhaul.

In addition to the fact that it is a much cheaper method, the use of special oil-control rings is frequently even more effective than boring the cylinders and installing new pistons equipped with rings of the original design. Two of the reasons for this are the difficulty in securing a correct alignment with the crankshaft of the newly bored cylinders and the greater distortion of the cylinders from the thinner walls.

Table 1—Piston-Ring Wear

	Case 1	Case 2	Case 3	Case 4
Mileage	8750	8300	1900	137,912
Test Run	Dynamometer	Dynamometer	Dynamometer	Road
Wear from Thickness				
1st Ring—Comp.	0.0015	0.0010[a]	0.0020 to 0.0025	0.034 to 0.047
2nd Ring—Comp.	0.0010	0.0007[a]	0.0015 to 0.0020	0.013 to 0.018
3rd Ring—Comp.	0.0010[a]	0.0007[a]	.....	0.015 to 0.020[a]
4th Ring—Oil	0.0015[a]	0.0010[a]	0.0035 to 0.0040	0.005 to 0.015[a]
Wear from Width				
1st Ring—Comp.	0.0005 max.	0.0005 max.[a]	0.0010 to 0.0015	0.0120 max.
2nd Ring—Comp.	0.0005 max.	0.0002 max.[a]	0.0005 to 0.0010	0.0060 max.
3rd Ring—Comp.	0.0005 max.[a]	0.0002 max.[a]	.....	0.0020 max.[a]
4th Ring—Oil	0.0005 max.[a]	0.0005 max.[a]	0.0003 to 0.0005	0.0015 max.[a]
Wear from Ring-Grooves	0.0002 max.	0.0003 max.	None	.....
Wear from Pistons	0.0005 max.	0.0005 max.	0.0005 to 0.0010	.....
Wear from Cylinders	0.0010 max.	0.0015 max.	0.0005 to 0.0010	.....

[a]Expander Rings

An example of this is given in Fig. 8, which is based on tests in an engine with only a nominal amount of wear. Two different makes and types of wide-channel oil-control rings gave approximately the same results, as indicated. The oil-consumption was cut just about in half by the use of special expander-type oil-control rings, this particular type consisting of two cast-iron sections of the hydraulic design. The cylinders were then bored and honed, and new pistons installed, equipped with wide-channel oil-rings. While the oil-consumption was less than with the wide-channel oil-rings before the boring and honing, it was still considerably greater than with the special oil-rings. While this is by no means always true, especially as conditions of wear become more severe, it indicates very definitely the place of expander-type rings in the piston-ring picture.

Objection to Expander-Type Rings

One of the greatest objections to the use of expander-type rings has been the possibility of a considerable increase in friction as a result of the greater pressure of the piston-rings against the cylinders, with the possibility of increased fuel-consumption, increased wear, and overheating. It is true that many expanders will give a very undesirable increase in friction, and many designs have caused excessive wear and even serious damage. For this reason, expanders and expander-type rings should never be used indiscriminately. However, when the expanders are properly designed, the increase in friction is not sufficient to be of importance, especially in view of the considerable improvement in oil-consumption that can be obtained. In Fig. 9, the friction horsepowers of these same rings are compared with those of the new engine. For each of the four speeds at which the readings have been plotted, the column on the left indicates the friction horsepower of the new engine after breaking-in. The second column gives the friction obtained through the installation of new rings of the original design, there being about 10,000 miles on the engine at the time. The third column indicates the friction after the reboring, the increase being due to the reduced piston-clearance. The fourth column shows results with the special expander-type rings.

From these figures it is apparent that, except at very slow speeds, the friction with the expander rings is less than that of the new engine and almost the same as in the rebored job. In no case is it sufficient to cause any appreciable increase in fuel-consumption or to cause any danger of overheating or increased wear. The maximum difference between the friction in those four installations is 3 hp. and, for the most part, it is not more than 1 hp. All of these friction readings were taken immediately after full-load runs while the engine was still at operating temperatures.

The wear of four different piston-ring installations is given in Table 1. The figures for three of these installations were obtained from dynamometer tests and one of them from actual service on the road. In the first case, the installation consisted of two compression-rings without expanders and one compression-ring and one oil-ring with expanders. The mileage was

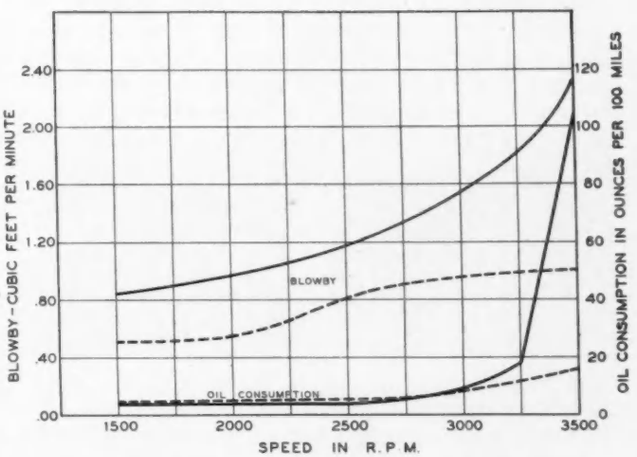


Fig. 12—Relation of Oil-Consumption and Blow-By to Speed

Fig. 13—Three Pistons from the Same Engine, in Various Stages of Ring-Sticking
In the piston on the right, the rings are all entirely free although carbon can be seen forming on the upper ring-land. In the center piston, the top ring has just become stuck in the groove, indicating the first step in this sticking procedure. The piston on the left has the upper two rings entirely stuck and completely covered with carbon. This sticking of the rings is due to abnormally high piston temperatures and will also result from insufficient side-clearance of the rings in the ring-grooves.

8750. The average wear from the face and from the sides of the rings is given. Note that the wear from the face and the sides of all of the rings is extremely small and that the expander-rings have not worn more than the rings without expanders. The wear is normally greatest at the top ring and decreases with succeeding rings down the piston. This is not true in the case of the oil-ring, because of its higher unit-pressure. In this case, with an expander-type oil-ring the wear was no greater than that of the top compression-ring and on all the rings was barely more than enough to remove the tool marks.

Wear from the ring-grooves was extremely small, the pistons showed almost no wear and the maximum wear of the cylinders was 0.001 in. In this case the expander-type compression and oil-control rings were of the two-piece cast-iron hydraulic-type. In the second case, which was run under similar conditions but in another engine, the test was run for 8300 miles, all four of the rings being of a single-piece expander-type, the oil-control ring being of a slotted design. Note that the wear of the rings was slightly less in Case 1, and the wear of the pistons and cylinders practically the same. These results would seem to indicate that with good clean oil and the absence of any abrasive material, differences in total pressures of the rings have little or no effect on the wear.

In Case 3, in still another engine, the test was run for only 1900 miles. During this test, which was run with conventional type piston-rings without expanders, cement dust from concrete being poured nearby got into the engine in spite of the air-filter. The effect of this abrasive material is at once apparent, as the wear of these rings is approximately twice as great as in Cases 1 and 2, with only one-fourth the mileage. The greater wear of the oil-rings shows the effect of the high unit-pressure of the wide-channel type when there is abrasive matter present.

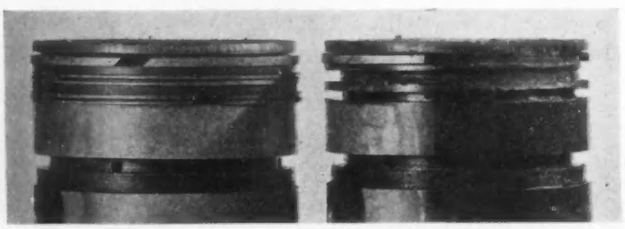


Fig. 14—Two Pistons from a Passenger-Car Engine, Showing the Effect of Wear Due to Abrasive Material
In one of the pistons, the effect of the wear can be seen in the increased side-clearance of the top ring. This increased clearance permits an excessive amount of blow-by, which eventually becomes sufficient to burn up the rings and the ring-grooves, as shown on the other piston.

Wear Largely Due to Outside Influences

From these three cases it appears that the wear of pistons, rings, and cylinders, is almost entirely due to factors which, though usually present, are outside influences. These include abrasive material entering with the intake air, crankcase sludge, excessive choking, cold starting and blow-by. Wear inside the cylinders cannot be eliminated without improved air-filters and oil-filters and improved cold-starting conditions. The normal lubrication of the cylinders as provided by the engine builders seems to be entirely adequate, and no improvement in this direction appears to be indicated.

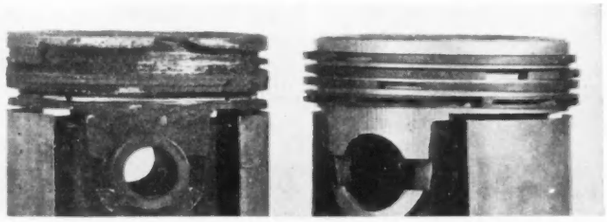


Fig. 15—Two Pistons from a Motor-Truck Engine, Showing the Effect of Wear from Abrasives
In this case, due to the design of the pistons, the principal wear is found in the second groove. One of the pistons has been cleaned-up and new rings have been mounted to show the true extent of the wear and pounding-out of the ring-grooves themselves.

In Case 4, wear figures are given for a run of extremely long duration in actual service on the road. The total mileage covered was 137,912. The wear from the top compression-rings was 0.034 to 0.047 in., rendering these rings entirely ineffective. The wear from the second compression-rings was also considerable, but they were still functioning. The third compression-ring and the oil-ring, both of the expander type, do not show any appreciably higher rate of wear as a result of increased pressure from the expander. Incidentally, the cylinder liners in this case were especially hard, running about 500 Brinell.

Unfortunately, the wear from the pistons and cylinders was not available; but, from the hardness of the cylinders, it is reasonable to expect that it was not extreme. Oil-consumption and fuel-consumption were satisfactory up to the last 10,000 miles of this run.

A number of factors other than piston-rings are of con-

siderable importance in their effect on oil-consumption. Because many of these are frequently overlooked, it was felt that some definite information on some of them would be of interest.

In road tests on a new truck-engine, experiments were conducted to determine the effect of different locations of the bleed-hole in the top half of the connecting-rod bearing. It was found that with the bleed-hole on the following-side of the rod, an oil-consumption of 150 to 200 miles per quart was obtained. By changing the bleed-hole over to the leading-side of the rod, the consumption was decreased to 500 to 600 miles per quart, this decrease being due to the lesser amount of oil thrown into the cylinders with the bleed-hole on the leading side.

High oil-consumption often is caused by leakage of oil into the combustion chamber around the intake valve-stems. Oil drawn through the valve-guides by the intake vacuum

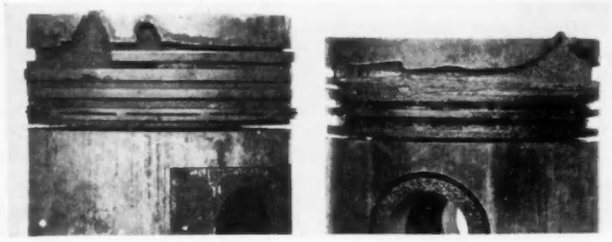


Fig. 16—Corrosive Effect of Hot Gases from Blow-By
Two pistons in which the top rings and ring-grooves have been entirely eaten away by the hot gases from blow-by, the blow-by being the result of excessive wear of the rings and of the ring-grooves due to abrasive material.

gives every indication of oil pumping past the pistons. The effect of this leakage in one particular case is shown in Fig. 10 in which the consumption in ounces per hundred miles is plotted at two speeds at which readings were taken. At 2500 r.p.m., 32 and 35 oz. per hundred miles were consumed. With the valve stems packed to prevent leakage, this was cut to 24 oz. per hundred miles, an improvement of almost 30 per cent. At 3000 r.p.m., the consumption was reduced approximately the same amount in ounces per hundred miles. These results do not necessarily mean that leakage through the intake valve-guides is independent of speed, but there can be no question that it can be of considerable amount and is an important factor.

In one engine with overhead valves, the valve cover was provided with louvers on the top, facing the back of the engine. The passage of air from the fan across the top of the engine drew fumes from the valve cover which were found to contain a considerable amount of oil spray. To check upon the actual amount of oil being lost in this manner, the louvers were soldered shut and a vent provided in the form of a pipe extending about 2 ft. above the engine, entirely out of the airstream from the fan. The improvement in consumption is indicated in Fig. 11, showing that a very appreciable amount of oil was being lost through the louvers.

Increase in blow-by does not always improve oil-consumption, as indicated in Fig. 12. In this particular case, the blow-by with one set of rings was so great that at 3500 r.p.m. a great deal of oil was forced out through the rear main-bearing. The extent of this leakage can be seen in the jump from 18 oz. per hundred miles at 3250 r.p.m. to 104 oz. at 3500 r.p.m. That speed alone was not the cause of the leakage through the rear main-bearing was determined by changing the rings and reducing the blow-by with the results indicated by the dotted lines.

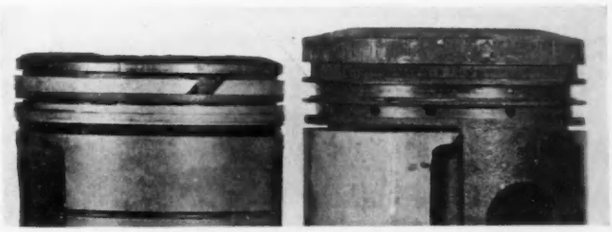


Fig. 17—Effects of Abrasive
Two illustrations of the extent to which abrasive can wear the rings and ring-grooves of a piston and of the extent of carbon formation that will be found behind these worn rings as a result of the high temperatures of the hot gases. Note the amount of carbon in the top ring-groove of the piston at the right, and the extreme pounding-out of the second ring-groove.

Piston and Ring Troubles Illustrated

Figs. 13 to 17 illustrate some of the points made. Fig. 13 shows three pistons from the same engine in various stages of ring-sticking. In the piston on the right, the rings are all entirely free although carbon can be seen forming on the upper ring-land. In the center piston the top ring has just become stuck in the groove, indicating the first step in this sticking procedure. The view on the left shows the upper two rings entirely stuck and completely covered with carbon. This sticking of the rings is due to abnormally high piston-temperatures and will also result from insufficient side clearance of the rings in the ring-grooves.

Fig. 14 shows two pistons from a passenger-car engine that indicate the effect of wear due to abrasive material. In one of the pistons the effect of the wear can be seen in the increased side-clearance of the top ring. This increased clearance permits an excessive amount of blow-by, which eventually becomes sufficient to burn up the rings and the ring-grooves, as shown on the other piston.

A similar case of two truck pistons is shown in Fig. 15, although, in this case, due to the design of the pistons, the principal wear is found in the second grooves. One of the pistons has been cleaned-up and new rings have been mounted to show the extent of the wear and pounding-out of the ring-grooves themselves.

Fig. 16 shows two more pistons in which the top rings and ring-grooves have been entirely eaten away by the hot gases from blow-by, the blow-by being the result of excessive wear of the rings and of the ring grooves due to abrasive material.

Fig. 17 is another view of the extent to which abrasive can wear the rings and ring-grooves of a piston, and the extent of carbon formation that will be found behind these worn rings as a result of the high temperatures of the hot gases. Note the amount of carbon in the top ring-groove of the piston at the right, and the extreme pounding-out of the second ring-groove.

The fact that these are mostly aluminum pistons is not intended to indicate that damage of this kind is more prevalent in aluminum than in cast-iron pistons. The same conditions will be found in cast-iron pistons.

It has not been the purpose to lead-up herein to any startling conclusions, but merely to present the effects of some of the many factors involved in piston and piston-ring performance in the hope that they might give a better comprehension of the problem and prove helpful in its solution.

Diesel Engines in Transportation

By O. D. Treiber
Hercules Motors Corp.

THREE sizes of six-cylinder Diesel-engines for automotive service have been developed by this company and are now in production, these being interchangeable in mounting dimensions with its six-cylinder series of gasoline engines.

These modern Diesels develop power which equals, or exceeds, that of a gasoline engine of corresponding displacement.

Subjects treated include noise, smoke, installation, performance, power output and maintenance, together with fuel and lubricating-oil costs.

A feature of these Diesels is a spherical combustion chamber located at the side of the cylinder with a spray of fuel entering at the side, below the center of the sphere but injecting across its center.

Comparisons between Diesel and gasoline-engine performance in similar service are made.

THE Diesel engine is of great interest to transportation executives because of the possibilities of reducing operating costs of automotive vehicles. A Diesel engine, as mentioned in this paper, is described as an internal-combustion compression-ignition injection-engine. The operating principles of this type of engine are quite generally known, as are the fuel requirements, the Diesel fuels being at present much cheaper per gallon than gasoline. With few exceptions, ordinary furnace oil is satisfactory, and its low price suggests operating economies that excite one's imagination. Some facts about Diesel engines for transportation service are presented herein for consideration.

The Hercules Motors Corp. has developed, and now has in production, three sizes of six-cylinder Diesel-engines for automotive service. These Diesels interchange in mounting dimensions with the Hercules "HX", "RX" and "JX" six-cylinder series of gasoline engines, and the Diesels are known as the "DHXB", "DRXB" and "DJXB" series. Figs. 1 and 2 show the "DHXB" and the "DRXB", which are typical automotive units. These modern Diesels develop power which equals, or exceeds, that of a gasoline engine of corresponding displacement. While the weight of the Diesel is slightly in excess of that of the gasoline engine, the increased weights have not proved to be a serious factor in vehicle applications. Perhaps other important questions are the suitability of an application as to noise, smoke, odor, vibration, acceleration and dependability.

Noise is more pronounced in a Diesel than in a gasoline engine, but experience with reasonably well-insulated footboards and dash results in nearly an equal condition with a gasoline engine when the vehicle is moving; however, the Diesel is more noisy when the vehicle is stopped and the engine is idling.

Smoky exhaust is always an item of concern. Some Diesels are inherently smoky, others are not, but any of them will smoke if not in a correct working condition. Smoke comes from two principal causes; first, from lubricating oil getting into the combustion chamber due to "carrying-by" the piston rings, or from excess oil on inlet-valve stems. Smoke from this cause is usually of a blue color, and has an obnoxious odor. Another cause of exhaust smoke is improper combustion of fuel oil. This smoke may be white, blue or black, and even a combination of all. The white smoke comes from a very slight oxidization of the fuel spray, or from slow combustion such as when starting a cold engine when the compression temperature is not hot enough to produce *complete* combustion, only a small amount of the fuel spray being partly oxidized. The power produced from cylinders discharging such an exhaust is usually nil.

Blue smoke also comes from an imperfect combustion, and can be the result of fuel-spray impregnment, or fuel spray oxidizing or burning in the outer stratas of the combustion chamber where the air is cooled slightly by the walls, thus

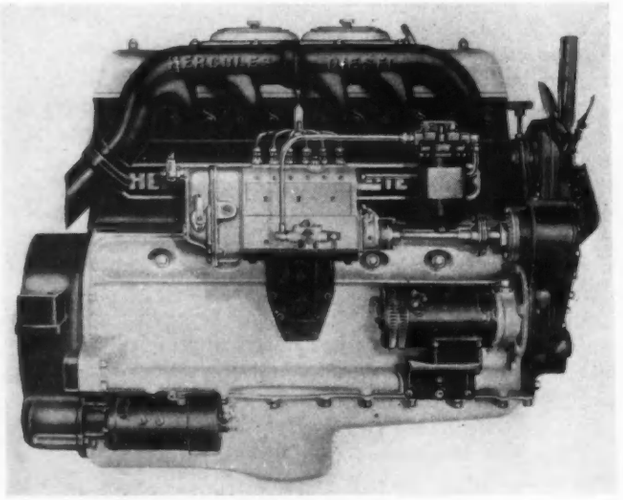


Fig. 1—The "DHXB" Hercules Engine

[This paper was presented at the Semi-Annual Meeting of the Society, White Sulphur Springs, West Va., June 18, 1935.]

preventing complete combustion. A crude example would be to drop oil on a stove at different places where temperatures differ greatly. The blue smoke that will roll out of a drop of oil suggests how a very little fuel spray out of place in the combustion chamber can cause so terribly much smoke. This smoke, either white or blue, has usually a very obnoxious odor, being composed largely of aldehydes, formaldehyde, and the like.

Black smoke is the result of poor combustion. It is composed of minute particles of carbon. The cause may be too much fuel for the available air; or, and most probably, there is not a proper *mixture* of the fuel and air in the combustion chamber at the *proper* time for combustion. This is the crux of Diesel-engine design. *It is the proper combination of a fuel spray and combustion chamber that perfects the job of mixing the fuel spray and air at a time and rate to provide complete combustion.* When these requirements are

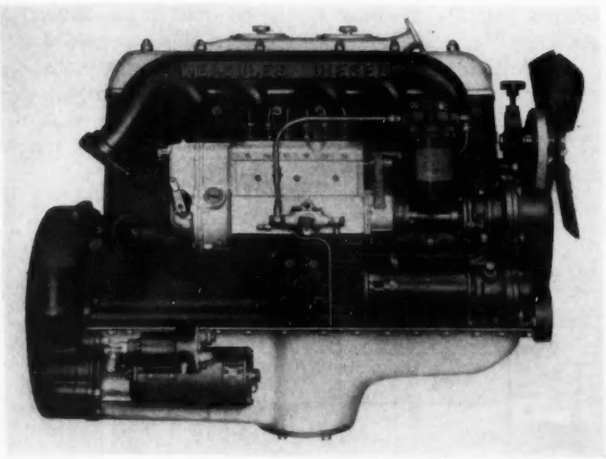


Fig. 2—The "DRXB" Hercules Engine

not satisfied, a Diesel engine will smoke and smell badly; but, when they are satisfied, these objections are overcome. Many and varied are the combinations of sprays and combustion chambers that have been projected, there are hundreds of them, but very few have found a place of command in commercial service.

In commercial-vehicle applications a Diesel engine must compete favorably with gasoline engines as to installation and performance, and the economy must be of sufficient importance to warrant the higher initial cost and justify, more or less, annoyances which usually accompany any new product. In installation, it must be comparable with gasoline engines in size and mounting dimensions, and in other features such as controls, exhaust, water connection, electrical equipment, clutch, and the like. In performance, it must have equal power and operate at approximately the same speed as do gasoline engines of similar size. Starting, acceleration and deceleration must be similar to those qualities in gasoline engines.

Perhaps the most important, and difficult, attainment is the power output in terms of mean effective pressure; with good economy, clean combustion, quietness and high speed, still having an engine compact, simple and sensible in design, and one easy of access, which can be maintained by an operator of average intelligence.

The greatest difficulty in maintenance in the old school of Diesel operation was the cleaning and adjusting of spray

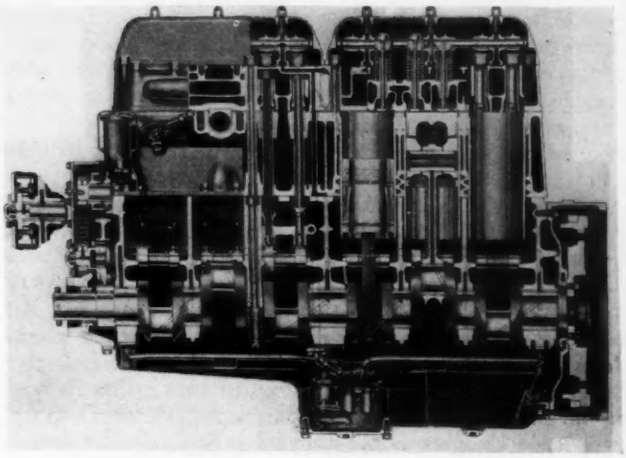


Fig. 4—Side Cross-Section of the Hercules Engine

nozzles; particularly, the cleaning of small-orifice nozzles where the fuel was sprayed into the cylinder through small holes of 0.008 to 0.012 in. in diameter. When these holes became clogged with dirt or carbon, it required an expert and special tools to clean them. To eliminate this difficulty, we began our program with the determination to use a pintle

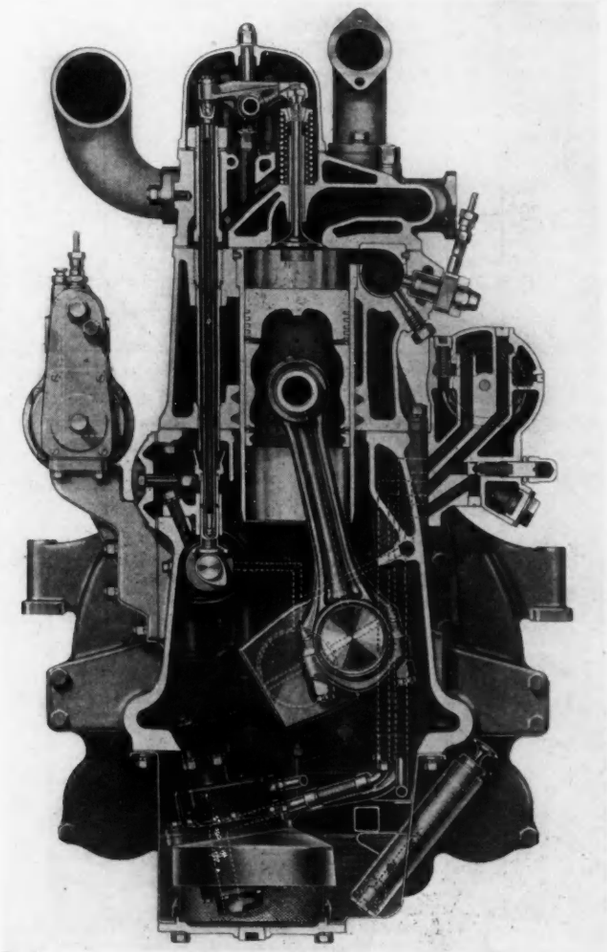


Fig. 3—End Cross-Section of the Hercules Engine

type or self-cleaning nozzle which would require no adjustments in the field and which any operator of ordinary intelligence could replace or clean if necessary. In conjunction with this feature, we made a great many investigations and carried out a great many experiments to find a type, shape and location, of combustion chamber to meet the exacting requirements.

The final design is a spherical combustion chamber located *at the side* of the cylinder, with a spray of fuel entering at the side, below the center of the sphere, but injecting across the center of the sphere. Fig. 3 and Fig. 4, cross-sections of the engine, show the details of this spherical chamber. An important feature of this type of chamber is that the piston closes the passageway between the cylinder and combustion chamber on the upper part of the piston stroke, thus *increasing the velocity of* the air passing from the cylinders into the combustion chamber *at the time when fuel injection occurs,* which greatly improves the mixing of the fuel with the air during the early part of the expansion stroke.

The earlier the fuel is burned on the expansion stroke, the greater are the power and the efficiency of the engine; so, it is extremely important to perform this operation of mixing fuel and air at a rate far in excess of any normal procedure which would come from a natural molecular movement of the combustion elements which, while rapid enough for slow-speed engines, would produce much-too-slow combustion for high-speed engines. In fact, since the high-speed engines are required to operate at wide speed-ranges, the *rate* of combustion should increase as *speeds increase*. The type of combustion chamber shown performs that function of increasing the rapidity of combustion with the increase in the speed of the crankshaft, with the result that indicated mean effective pressure increases with increase in speed. Furthermore, the nature of this type of combustion chamber lends itself favorably to prevent fuel being burned adjacent to cold walls. These walls are formed from separate pieces inserted in the cylinder block and head, and do not readily radiate the heat into the cooled walls. But of more importance is the *density of the air* revolving at very high velocity in the sphere, which is greater than the particles of fuel spray and, consequently, the fuel spray is kept away from these walls and slow incomplete combustion is prevented.

The power curves in Fig. 5 and Fig. 6 show the results of dynamometer tests. The economy, as plotted in mean effective pressure at 1000 r.p.m. on the larger engine, is shown in Fig. 7. These results exceed those generally considered possible with a Diesel engine, and are accounted for in the design of this combustion chamber. These high mean effective pressures make possible a power output with the Diesel equal to that of a gasoline engine of similar weight and displacement.

The economy shown on these curves, corresponding to

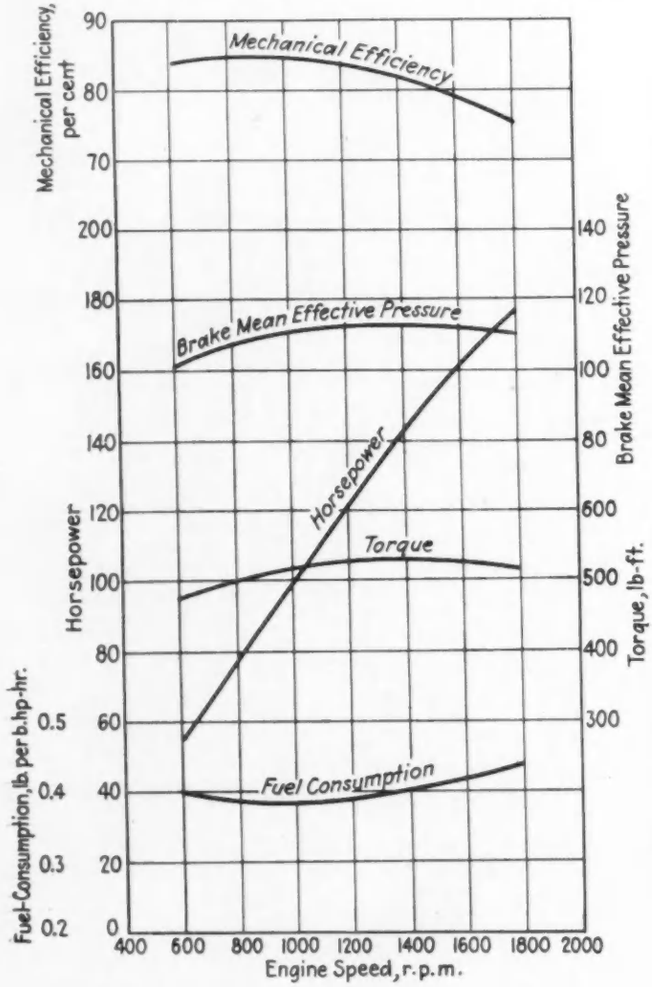


Fig. 5—Power Curves of the "DHXB" Hercules Engine

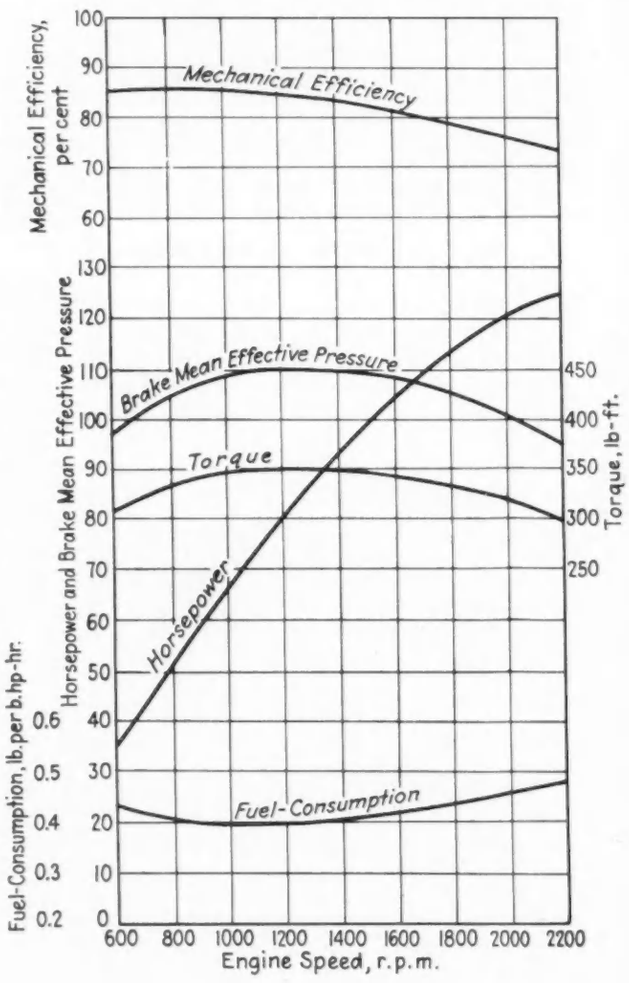


Fig. 6—Power Curves of the "DRXB" Hercules Engine

these powers, is the justification for the use of the higher-cost Diesel-engine over a gasoline engine. These present higher costs of a Diesel are due to the additional cost of injection equipment over carburetor and ignition equipment, the additional metal in the Diesel engine, and some increase in the cost of electrical starting equipment, all of which will probably be lowered as the volume of Diesel production increases.

Some comments on the probable savings that may be expected from a Diesel are of interest. These savings result from two things, the cheaper fuel used and the smaller quantity used per horsepower, than with gasoline engines. The much-discussed subject of fuel cost, which some think may be increased to the price of gasoline should the Diesel engines be quite generally adopted, is perhaps easily answered when we consider that all fuel oil and gasoline are made from

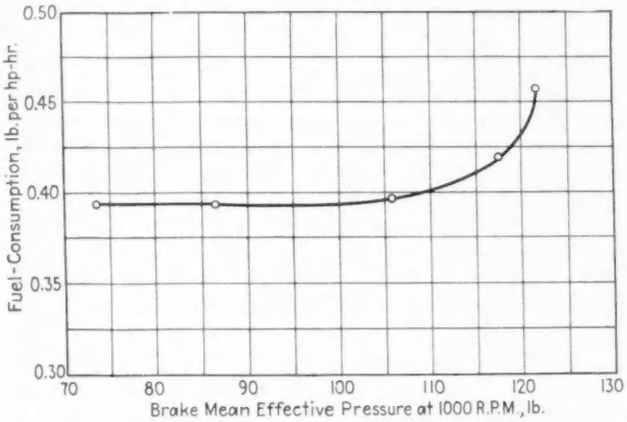


Fig. 7—Fuel Economy of the "DHXB" Hercules Engine

This is a six-cylinder engine of 5-in. bore and 6-in. stroke. The displacement is 705.85 cu. in. and the compression ratio, 15.8 to 1. No. 2 Furnace Oil was used.

crude petroleum. The crude often contains grit and sludge, which prevents its general use in a Diesel. The refining to produce gasoline always leaves an amount ordinarily used as furnace oil and is quite generally acceptable for Diesels. The greater the quantity of gasoline the refiner wishes to obtain from the crude, the greater is the expense in refining. The greater the demand for furnace or Diesel oil, and the less for gasoline, the less expense to the refiner in refining a barrel of crude. As to how prices of the different products will be apportioned, this is purely a matter of market demands and economies of the user.

At present, great quantities of fuel oil are burned in furnaces, with only a slight margin of advantage over coal or lignite, as to cost and the like. With only a slight increase in fuel-oil prices, these great quantities of furnace oil would not be absorbed for furnace use, and a balance is thus attained. However, the natural result of competition would indicate that, if costs are lower to produce a barrel of fuel oil suitable for Diesels than to produce a barrel of gasoline, the Diesel fuel would be cheaper to the user. If, however, the *same price* were paid for Diesel fuel and gasoline, the cost of fuel would show approximately 50 per cent savings in favor of the Diesel on the basis of about one-half the quantity being required for the Diesel.

The lubricating-oil expense probably will be about equal, but the maintenance may be somewhat higher for the Diesel. However, the economy of the Diesel is dependent to a con-

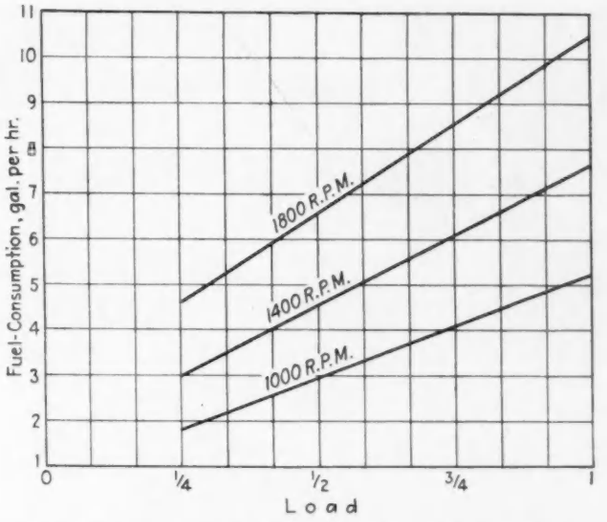


Fig. 8—Approximate Fuel Consumption for the "DHXB" Hercules Engine at Sea Level

siderable extent in many applications on the use of proper gear-ratios. Because of increased economy of the Diesel, below the higher speed-ranges, there is better economy when operating at approximately two-thirds to three-fourths of the maximum speed than at maximum governed speed. Furthermore, the torque of the Diesel is probably increased more, with a decrease in speed than in gasoline engines in actual service, even though the dynamometer tests would not show it. And, probably, this holds the explanation of why the Diesel seems to have a greater torque when climbing grades and the engine revolutions are decreasing. This may also be the reason why it often appears to be possible to pull grades in a higher gear with a Diesel than with a gasoline engine of presumably equal power and torque.

We are not prepared to say just what the gear ratio should be, but are inclined to believe from our experience that those ratios suitable for gasoline engines are not always the best for Diesels. Perhaps some explanation should be given why speeds lower than maximum should give better road economy. The explanation is due in part to friction, which increases with speed very rapidly, but more particularly to injection characteristics; that tendency of the duration of the spray to spread over a longer period of crankshaft angularity as speeds increase.

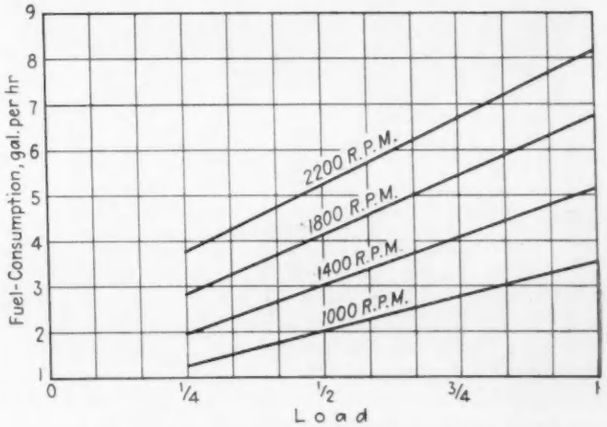


Fig. 9—Approximate Fuel Consumption for the "DRXB" Hercules Engine at Sea Level

Fig. 10—Hercules-Diesel-Powered Twin-Coach

Fig. 11—Hercules "DHXB" Engine Installed in a Marmon-Herrington Caravan-Coach

Fig. 12—Hercules "DHXB" Engine Installed in a White-Indiana Truck

Fig. 13—Hercules "DRXB" Engine Installed in a Moreland Truck

Fig. 14—Hercules "DRXB" Engine Installed in a White-Indiana Truck

Figs. 8 and 9 show the fuel consumption in gallons per hour at various engine speeds—that is, at one-fourth, one-half, three fourths and full load, transposed from pounds per horsepower hour—based upon dynamometer tests of the "DHXB" 5 x 6-in. and the "DRXB" 4⅜ x 5¼-in. six-cylinder Diesels.

In selecting a combination of injection equipment to have the proper characteristics as to duration at maximum high speed, it has its disadvantages at the lower speeds of making the engine rough, noisy, and the timing becoming very sensitive; so, a compromise of injection equipment must be selected. But like all other engineering problems when they can be understood clearly and stated, they are improved by progressive engineers in that line of endeavor, and undoubtedly these features will be greatly improved as time goes on, resulting in even greater engine efficiency and economy than is possible today.

Some typical applications of the Hercules engines are shown in Figs. 10 to 16, although no operating costs are presented. Since our policy is to sell our product to the various *manufacturers,* rather than directly to an operator, our customers, the manufacturers to whom we sell, are relied upon by us to secure and supply operating-cost figures on our Diesels, as they have done for many years in connection with our gasoline engines.

We have found also that actual operating data are subject to considerable variation, since it is almost impossible to get information of this kind which covers identical conditions. And since these conditions are not similar, information of this nature loses its comparative value, although it may indicate in a general way the economies that might be effected.

Fig. 15—Hercules "DRXB" Engine Installed in a Euclid Trac-Truk

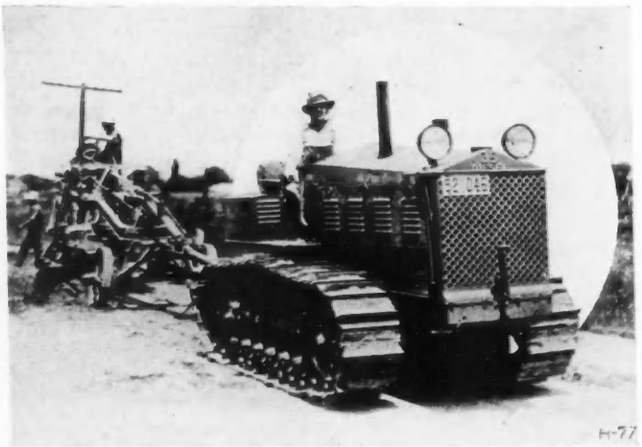


Fig. 16—Hercules "DHXB" Engine Installed in a Cletrac

Thermodynamic Note Discussing Rassweiler-Withrow Paper

By R. L. Sweigert
Georgia School of Technology

IN summarized form it was stated in connection with the paper on "Flame Temperatures Vary with Knock and Combustion-Chamber Position," by Gerald M. Rassweiler and Lloyd Withrow, published in the S. A. E. JOURNAL, April, 1935, beginning on page 125, that "temperature measurements have been made along three lines through the combustion chamber of a gasoline engine running under non-knocking and under knocking conditions. The results show that, after passage of the flame fronts through portions of the charge located either near the point of ignition or near the center of the combustion chamber, the temperature rises continually until shortly before maximum pressure is reached.

"When the charge is completely inflamed, there is a temperature gradient along the length of the combustion space, the temperature at the spark-plug end being as much as 600 deg. fahr. higher than at the opposite end. These effects are explained on the basis of adiabatic compression and expansion of the gases during the combustion process."

In the following thermodynamic note, the author analyzes the details of the combustion process, stating that the mechanism used has been quite well verified by experiment.

Three diagrams and three equations are used to illustrate the analysis.

IN the following thermodynamic study of the combustion mechanism of an engine, recently completed, I have attempted to analyze the details of the combustion process. The mechanism used has been quite well verified by experiment.

Using the same mechanism, a very simple analysis can be applied to check the results of Rassweiler and Withrow. Considering the first portion of the charge to burn adiabatically, that is, that there is no heat transfer, an equilibrium pressure p_o, and an equilibrium temperature T_o, are obtained by constant-volume combustion. The nature of the conditions present in a combustion chamber make the most reasonable assumption, that of constant volume. In fact the engine conditions, practically, help to eliminate other possibilities. The values of p_o and T_o depend upon p_c and T_c, the conditions at the end of compression by the piston. The first portion of the charge is compressed by the last part of the charge to burn, so that the final pressure and temperature of the first portion after compression is p_2 and T_2. The last portion of the charge to burn is not burned at p_c and T_c, due to its earlier compression by the first part of the charge burned. Thus the last portion of the charge burns at p_c' and T_c' not p_c and T_c. The last part of the charge reaches an equilibrium pressure and temperature of p_o' and T_o'. It then expands, compressing the first portion, the final portion reaching a pressure and temperature of p_2 and T_2', the pressure in the chamber being equalized.

It may be noted that there is a shifting equilibrium as combustion proceeds. Fig. 1 illustrates the equilibrium pressures and temperatures as combustion proceeds.

For the first portion, due to compression, we may write

$$\left(\frac{p_o}{p_2}\right)^{\frac{n-1}{n}} = \frac{T_o}{T_2} \tag{1}$$

or

$$T_2 = T_o\left(\frac{p_2}{p_o}\right)^{\frac{n-1}{n}}$$

the temperature of the first portion. Similarly, for the expansion of the last portion, we may write

$$\left(\frac{p_o'}{p_2}\right)^{\frac{n-1}{n}} = \frac{T_o}{T_2'}$$

or

$$T_2' = T_o'\left(\frac{p_2}{p_o'}\right)^{\frac{n-1}{n}} \tag{2}$$

in which T_2' is the temperature of the last portion to burn.

Dividing (1) by (2) we have

$$\frac{T_2}{T_2'} = \frac{T_o}{T_o'}\left(\frac{p_o'}{p_o}\right)^{\frac{n-1}{n}} \tag{3}$$

It is readily seen from Equation (3) that the results obtained by Rassweiler and Withrow can be explained by the shifting equilibrium, which exists during the combustion process. Equilibrium temperatures are not greatly affected by the pressure changes as they exist in the engine. Thus T_o and T_o' will not differ greatly. However, due to the condition that the last portion of the charge to burn, burns at a pressure p_c', which is considerably greater than p_c, the pressure at the end of piston compression, the pressure p_o' will be considerably greater than p_o. These values are indicated in Fig. 1. Thus it may be seen from Equation (3) that T_2/T_2' is greater than 1.00, or the final temperature of

the first portion of the charge to burn is greater than the temperature of the last portion of the charge to burn.

From Equation (3) also, if it were desirable, an analysis of all factors affecting this temperature difference could be made, both qualitatively and quantitatively. An equation, similar to Equation (3), would give the temperature in the middle of the chamber. The trend of the calculated results lines up with the trend of the experimental results. The method may be applied to both knocking and non-knocking conditions;

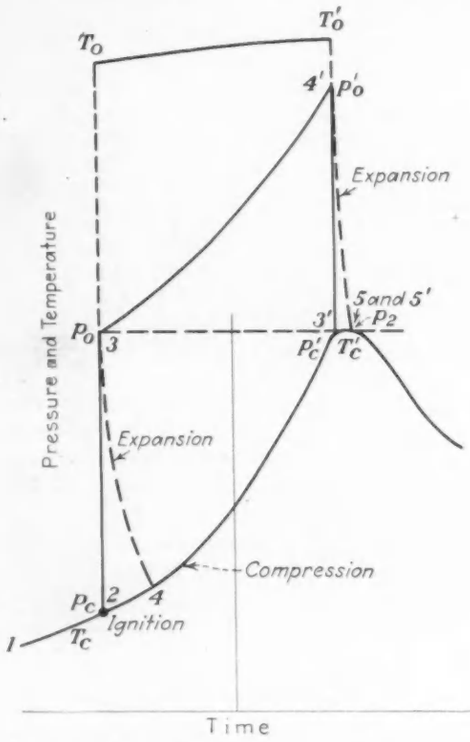


Fig. 1—Illustration of the Equilibrium Pressures and Temperatures as Combustion Proceeds

however, for the non-knocking condition, elemental burning proceeds completely across the chamber, whereas, in the knocking condition, the elemental burning does not exist in the last portion of the charge to be burned.

With a given set of conditions, T_o was found to be 5200 deg. R. or degrees absolute; T_o', 5370 deg. R.; p_o, 660 lb.; and p_o', 2080 lb. From Equation (3), T_2/T_2' is equal to 1.22. All the values indicated, can be calculated for any given situation, if they are wanted.

While the actual results, due to imperfections, will naturally vary from those calculated, they, nevertheless, give analytical results for many practical purposes. Also, the checking of experimental results by theory gives a much more complete picture of a given situation than either one alone.

As already mentioned, the differences in temperature come about through the fact that compression pressures in the range of those present in the engine do not materially affect the equilibrium temperatures, while the equilibrium pressures are affected. Figs. 2 and 3 help to illustrate the situation.

Thus it is shown that the temperature differences obtained are thermodynamically logical.

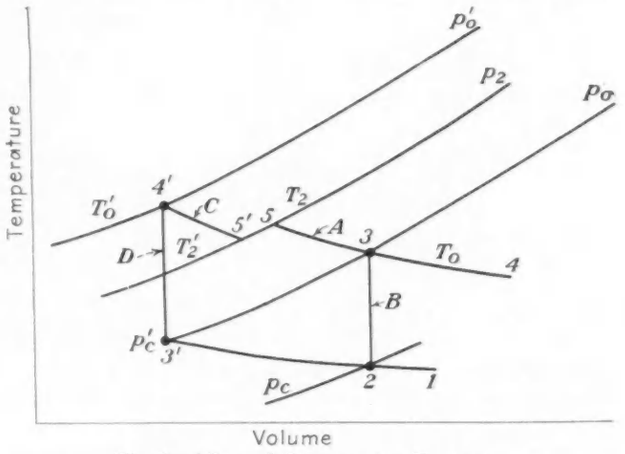


Fig. 2—Affect of Compression Pressures

A = Compression of the first portion
B = Combustion of the first portion
C = Expansion of the last portion
D = Combustion of the last portion

The numbers on Figs. 1, 2, and 3 show the following processes:

1-2 piston compression of whole charge
2-3' compression of unburned portion by burned portion
3'-4' combustion of last portion of charge
4'-5' expansion of last portion of charge to burn
2-3 combustion of first portion of charge
3-4 expansion of first portion of charge to burn
4-5 compression of first portion of charge burned by the later portions of the charge to burn.

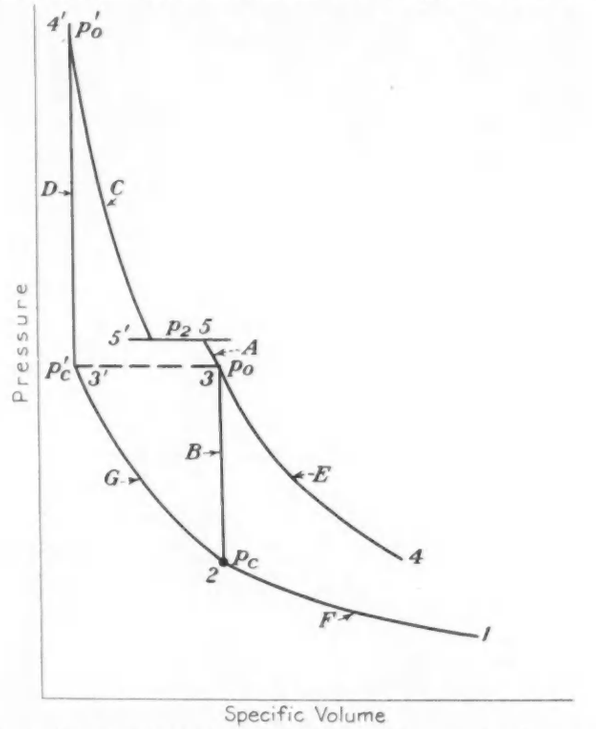


Fig. 3—Further Illustration of the Affect of Compression Pressures

A = Compression of the first portion
B = Combustion line of the first portion
C = Expansion of the last portion
D = Combustion line of the last portion
E = Expansion of the first portion, followed by compression
F = Piston compression
G = Combustion compression

Make S. A. E. Headquarters

Your Headquarters

DURING NEW YORK SHOW WEEK

S.A.E. headquarters, always eager to welcome members when they are in New York, is making special preparations to serve you during New York Automobile Show Week, beginning November 2.

If you will let Miss J. A. McCormick of headquarters know of your arrival, she will be glad to tell your other S.A.E. friends where you can be reached—and to help you to get in touch with friends whom you may want to see.

You may want to make headquarters a meeting place. A small comfortable lounge room will be available right on the 7th floor of 29 West 39th St., for that purpose.

Above: Miss J. A. McCormick, assistant office manager, will be on duty at the reception desk for Show Week. *At left:* S.A.E. Headquarters is close to all points of automotive interest in New York

You may want to drop in to see some of the staff members; to check up on the availability and scope of some Society service that you aren't entirely familiar with; to make reservations for the S.A.E. Annual Dinner (Hotel Commodore, Monday, November 4); to check up some reference that has been bothering you; to learn about any one of a score of things that S.A.E. men are interested in.

Whatever it may be, headquarters will help you to get the most out of your New York visit. The staff won't know the answers to everything by a long shot, but is going to assist as best it can.

Come to S.A.E. headquarters—7th Floor, Engineering Societies Building, 29 West 39th St.—at least to say "Hello" if you get to New York during Automobile Show week.

About S.A.E. Members:

Igor I. Sikorsky, engineering manager of the Sikorsky division of United Aircraft, has been awarded the honorary degree of Master of Science by Yale University. In conferring the degree on Mr. Sikorsky, President Nettleton of Yale said: "He is, by reason of his supreme contributions to the practice of international air transportation and to the principles of international cooperation and friendship, a citizen of the world."

"Citizen of the World"

Igor I. Sikorsky

Some of his recent work on large flying boats, for whose development he has received many previous honors, was described by Mr. Sikorsky in a paper presented at the last Semi-Annual Meeting of the Society and printed in the July issue of the S.A.E. JOURNAL. He has been a member of the S.A.E. since 1930.

Henry J. White, foreign aviation representative of the Socony-Vacuum Oil Co., has been transferred from the New York office of the company to the London office at Caxton House, Westminster, S. W. 1. Mr. White had been designated to serve on the Aircraft and Aircraft Engine Activity Committee of the Metropolitan Section of the Society.

A. V. D. Willgoos (M '20) and *C. J. Marks* (M '26) are among the original employes of the Pratt & Whitney Aircraft staff who are participating in the company's celebration of its tenth birthday. In the infant organization of 1925 Mr. Willgoos was an engineer and Mr. Marks was in charge of tooling arrangements. Today Mr. Willgoos is chief engineer of the company and Mr. Marks is production engineer.

W. B. Sullivan, former vice-president and general manager of the Michigan Products Corp., is now in charge of the alloy department for the Lebanon Steel Foundry, Lebanon, Pa.

Aleksander Senkowski writes that the Polish Skoda Works for which he was production manager, has been acquired by the Polish Government and is being operated under the name of Panstwowe Zaklady Lotnicze Wytwornia Silnikow (Government Aircraft Establishments, Engine Works). In the new organization Mr. Senkowski's title is works manager in charge of production.

Irving B. Babcock has been advanced to the presidency of the Yellow Truck and Coach Mfg. Co., from his former position of executive vice-president. Mr. Babcock has been with General Motors' truck manufacturing companies since 1920. His new position includes the general management of the General Motors Truck Corp. and General Motors Truck Co. He succeeds *Paul W. Seiler,* who has resigned as president and general manager of the companies, but retains his directorate in the Yellow Truck and Coach Mfg. Co.

Louis Thoms has joined the export division of the General Motors Corp. as assistant to the vice-president in charge of engineering. Recently, as announced in the September issue of the S.A.E. JOURNAL, he resigned as chief engineer of the Graham-Paige Motors Corp.

R. W. Fulton is manager of Fink-Dumont-White, Inc., manufacturers' agents in New York.

James R. Fitzpatrick, who recently resigned as vice-president of the Haskelite Mfg. Corp., is now director of sales for the technical division of the Algoma Plywood & Veneer Co. Headquarters of the division is in Chicago.

Maxwell Halsey, assistant director of the Harvard Bureau for Street Traffic Research, has been named to the traffic staff of the "National Crime School" to be conducted by the Bureau of Investigation of the Federal Department of Justice. The traffic course will cover such problems as the social and economic effects of congestion and accidents in traffic, the modern organization of police departments to cope with the traffic problem, the relations of enforcement agencies with the public, and the technique for prevention and punishment of traffic violations.

Named to Aid Police School

Maxwell Halsey

Arthur N. Lappin has joined the Crouch-Boles Aircraft Corp., Pawtucket, R. I., as assistant engineer.

John F. Young, formerly service division manager at the Buffalo, N. Y., plant of the Ford Motor Co., has been assigned as the company's service representative at its exhibit at the California Pacific Exposition, San Diego.

H. D. Church resigned, effective Aug. 31, as vice-president in charge of engineering of the Winton Engine Co., General Motors subsidiary. In leaving the employ of the General Motors Corp., Mr. Church announced that he had no immediate plans for the future.

Donald L. Bower is now connected with the U. S. Engineer's Office at Elmira, N. Y., where he has been designated to take charge of a damage survey of areas recently flooded in New York and Pennsylvania. Until recently Mr. Bower was assistant to the executive engineer of the National Resources Board and assistant secretary of the Mississippi Valley Committee.

John V. Pugh

John V. Pugh, of Folkestone, England, who has been a member of the S.A.E. for a matter of 22 years, recently radioed the Society as follows:

PLEASE SEND ME TWENTY-FOUR COPIES JULY JOURNAL AND FIFTY MEMBERSHIP APPLICATIONS AM OPERATING ON SEVENTY MEMBERSHIP PROSPECTS

Even in the heyday of the "Get Your Man" Campaign, no such incident of that magnitude occurred in the daily routine of the Society's operations. Gentlemen, meet Mr. Pugh!

The Rudge-Whitworth wire wheel, of which he was patentee as a director of Rudge-Whitworth in 1922, is still a live topic of discussion in many quarters. But the wheel invention was only an incident in a rich and crowded career, which leaves Mr. Pugh with the chairmanship of the Charles H. Pugh Co., Birmingham, England, as his most active business interest. He is a past president of the Union of British Cycle and Motorcycle Manufacturers and Traders and is, or has been, director and engineer for more British companies than you can count on your two hands.

Lloyd Stearman is with the Bureau of Air Commerce, Washington, as aeronautics development engineer.

Stephen J. Zand sailed for Paris Aug. 24 to work on assignment for the remainder of the year with the French Air Ministry. Mr. Zand, who is aeronautical research engineer with the Sperry Gyroscope Co., Inc., has specialized on the problems of silencing aircraft noises. His address in Paris will be c/o Frank Delves, 117 Rue de Caulaincourt.

Back to Birthplace

Stephen J. Zand

Paris is not unfamiliar ground to Mr. Zand. He was born there, served during the World War with the aviation branch of the French army (promoted captain, 1918) and later was a designer with the Hispano-Suiza organization.

. . . . At Home and Abroad

Capt. Walter C. Thee, Q.M.C., U.S.A., has been assigned to the Quartermaster Corps School at the Schuylkill Arsenal, Philadelphia. Until recently he was in charge of the Second Corps Area Motor Repair Shop at Fort Hancock, N. J.

Walter Leveau on Oct. 1 became general manager of the Jack Dunn Chris-Craft, Inc., Miami, Fla. Until that time he was chief designer for the Horace E. Dodge Boat & Plane Corp., Newport News, Va.

W. E. Blaine is now in charge of the recently opened Detroit office of the Chek-Chart Corp., 2-113 General Motors Bldg.

Charles Richard Fairey, chairman and managing director, Fairey Aviation Co., Ltd., Hayes, England, may become the next challenger for the America's Cup, premier prize in international yachting circles. Mr. Fairey, who was recently elected commodore of the Royal London Yacht Club, witnessed the cup races in American waters last year when his friend T. O. M. Sopwith made an unsuccessful bid for the prize with "Endeavour."

Prof. Dr. Ernst A. Hauser, chief chemist in charge of research and head of the patent department, Semperit-Austrian-American Rubber Works Co., has left Vienna, and may be addressed c/o Department of Chemical Engineering, Massachusetts Institute of Technology, Cambridge.

Mason D. Hanes, formerly engineer on engine design with the General Motors Truck Corp., has joined the Pratt & Whitney Division of United Aircraft at East Hartford, Conn.

Arnold G. Parker is now connected with Noorduyn Aircraft, Ltd., St. Laurent, P. Q., Canada, as designing engineer and draftsman.

R. R. Faller, automotive engineer with the Ethyl Gasoline Corp., is now making his headquarters in Cincinnati.

Kenneth M. Lane is in private practice as a consulting aeronautical engineer at 232 Claremont Rd., Ridgewood, N. J.

William H. Welch, formerly chief spark plug engineer for the Firestone Tire & Rubber Co., is now spark plug consultant for a number of independent companies. His address is 844 Chestnut Blvd., Cuyahoga Falls, Ohio.

George J. Liddell, formerly test engineer for the Doherty Research Co., is now automotive engineer in the Pittsburgh region for the Sun Oil Co., Philadelphia.

Cyril C. Lawton, formerly with the White and Bagley Co., Worcester, Mass., is now on duty as Captain, Office of the Motor Transportation Officer, Fort Devens, Mass., the headquarters of the third district, Civilian Conservation Corps.

Members Help Design New Navy Plane

The first plane produced at the Naval Aircraft factory, Philadelphia, under the provisions of the Vinson-Trammel Act was flown on August 27, by the Navy personnel at Philadelphia. This act, authorizing construction of naval vessels to treaty strength, provided that 10 per cent of the aircraft built should be constructed in factories operated by the U. S. Government.

Nearly a dozen members of the S.A.E. had some part in the development of this interesting plane—the third type of training plane constructed by the Navy—which will be delivered to the Flight Test Section at Anacostia, D. C., for the regular tests required by the Navy for all commercially built planes. The S.A.E. men

(*Continued on page* 34)

Anthony H. G. Fokker arrived in the United States per "Normandie" on August 19. On landing he said that he had spent the last two months traveling over Europe to introduce the Douglas transport airplane.

"Flying Dutchman" On Shipboard

Wide World Photo

Anthony H. G. Fokker

John N. Willys Dies in His New York Home

John N. Willys

John North Willys, manufacturer of automobiles bearing his name since 1907 and Ambassador to Poland under President Hoover, died in September of heart disease. He was 61 years old.

One of the best-known figures in the automobile industry, Mr. Willys had been an associate member of the Society since 1911. Although no stranger to business depressions (his business was founded subsequent to the panic of 1907 and encountered stormy weather both in 1922 and following 1929), Mr. Willys was a perennial optimist and became celebrated on both sides of the Atlantic for his sturdy refusal to whine in the face of adversity.

Beginning business as a bicycle agent, Mr. Willys sold his first automobile in 1901. In 1906 he organized the American Motor Car Sales Co. with a franchise for a large territory and a contract to take the entire output of the Overland Co. of Indianapolis. With orders in his pocket for 500 Overland cars, Mr. Willys found the manufacturing company facing bankruptcy. He raised money to enable the company to continue and thereby obtained control. A circus tent provided the first addition to a factory. Hearing casually that the Toledo-Pope Co. factory was for sale, he bought it within 48 hours and moved production of the Overland car to Toledo. The production in 1907 was 400 cars; the factory turned out 4000 in 1908 and 13,000 in 1909. From then on the venture was an established success reaching a production of 40,000 cars a year in 1913.

The Spring of 1922 found the company with a deficit of more than $20,000,000 and bankers demanding settlement. In a little more than a year $17,000,000 of the debt was paid off. By the end of 1924, creditors were paid in full.

In 1928 Mr. Willys sold his common stock in the Willys-Overland Co. for $25,000,000 and accepted the ambassadorship to Poland. With the company again facing receivership in the following years, Mr. Willys returned to the United States and became active again in its affairs.

New Members Qualified

These applicants who have qualified for admission to the Society have been welcomed into membership between Aug. 10, 1935, and Sept. 10, 1935.

The various grades of membership are indicated by: (M) Member; (A) Associate Member; (J) Junior; (Aff.) Affiliate Member; (SM) Service Member; (FM) Foreign Member.

ANDERSON, DEWEY (A) service manager, Sunset Electric Co., 11th and East Pine, Seattle, Wash.; (mail) 5017 Meridian.

BODEN, HAROLD (A) partner, Boden & Bassingthwaite, Toronto, Ontario, Canada; (mail) 45 Warland Avenue.

BUTLER, HERBERT W. (A) assistant service manager, General Motors Peninsular, S. A., Barcelona, Spain.

DALLMANN, ELMER A. (J) sales engineer, Perfex Radiator Co., Milwaukee; (mail) 2101 West Clarke Street.

ECKER, LYLE G. (A) engineer, United Parts Mfg. Co., 1315 West Congress Street, Chicago; (mail) 1055 Granville Avenue.

HALL, GEOFFREY WILLIAM (FM) manager, engine experimental department, Fairey Aviation Co., Ltd., Hayes, Middlesex, England.

HALL, ROBERT GUY (A) district service manager, General Motors Fleet Sales Corp., Detroit; (mail) 1907 Tower Petroleum Building, Dallas, Tex.

HERNE, CAPT. E. D. C. (M) sales engineer, Chrysler Corp., Detroit.

KEITH, P. C., JR. (M) vice-president, M. W. Kellogg Co., 225 Broadway, New York City.

KONISHI, S. (FM) chief designer, automotive department, Tokyo Gasudenki Kogyo K. K., Omori, Tokyo, Japan; (mail) 453-1 Chome, Chofuminemachi Omori-Ku, Tokyo, Japan.

LILYGREN, ALBERT J. (A) Northwest zone manager, Bendix Products Corp., 6516 31st Street, North East, Seattle, Wash.

MACGREGOR, THOMAS DOUGLAS (J) graduate student, New York University, New York City; (mail) 3 Claremont Road, Scarsdale, N. Y.

MANSON, ARTHUR (A) owner, Garden City Sales & Service Co., 447 South First Street, San Jose, Calif.

MERRILL, MARCELLUS S. (M) owner, Merrill Axle-Wheel Service, 1230 Lincoln Street, Denver, Colo.; (mail) 345 Clarkson.

MOLLER, JOSEPH A. (M) engineer, Pure Oil Co., 35 East Wacker Drive, Chicago.

MORFE, JOSEPH D. (A) superintendent of maintenance, Overnight Motor Transportation Co., 101 South Fremont Avenue, Baltimore, Md.; (mail) 1013 Rosedale Street.

ORLANDO, ALEXANDER (FM) director, Ala Littoria S. A., Venice, Lido, Italy.

SCHULTZ, WILLIAM P. (A) superintendent, automotive maintenance department, Wilson & Co., 816 First Avenue, New York City; (mail) 111-18 169th Street, Jamaica, L. I., N. Y.

SHEBAT, HERBERT V. (M) engine pilot, Wright Aeronautical Corp., Paterson, N. J.; (mail) Happy Landings, Caldwell, N. J.

SMITH, HOWARD M. (A) bus foreman, Southern Pennsylvania Bus Co., 1300 Edgmont Avenue, Chester, Pa.

STEARMAN, GLENN A. (J) layout drafting, Chance Vought Corp., East Hartford, Conn.; (mail) 846 Main Street.

STEIN, GEORGE F. (J) student, Boeing School of Aeronautics, Oakland Airport, Oakland, Calif.; (mail) Post Office Box 284, Bishop, Calif.

SUTTON, PHILIP G. (A) general manager, Emich Motors Corp., 133 West Madison Street, Oak Park, Ill.; (mail) 3057 North Spaulding Avenue, Chicago.

UNTERMYER, SAMUEL, 2nd (J) fuel tester, Sinclair Refining Co., East Chicago, Ind.

WILLETT, HOWARD L., JR. (J) superintendent, maintenance, 700 South Desplaines, Chicago.

Applications Received

The applications for membership received between Aug. 15, 1935, and Sept. 15, 1935, are listed herewith. The members of the Society are urged to send any pertinent information with regard to those listed which the Council should have for consideration prior to their election. It is requested that such communications from members be sent promptly.

BLANCO, PABLO L. DORIGA, manager, Sociedad Espanola del Acumulador Tudor, Victoria 2, Madrid, Spain.

CAMPBELL, JAMES H., assistant service manager, Howard Motor Co., Seattle, Wash.

CHEN, CAPTAIN CHIH, 5005 13th Street, N. W., Washington, D. C.

COLSTON, LEONARD ANDREW, assistant chief engineer, Romec Pump Co., Elyria, Ohio.

DIEHL, HOWARD CHARLES, purchasing agent, Theurer Wagon Works, Inc., New York City.

DOLING, CHARLES E., vice-president, Autocar Sales & Service Co., Inc., New York City.

ELDEN, HOWARD E., technical manager, Dunlop Tire & Rubber Co., Buffalo, N. Y.

ELVEY, ERNEST WILLIAM, mechanical supervisor, Taylor Pearson & Carson Ltd., Calgary, Alta., Canada.

FLERACKERS, OSCAR, chief engineer, Sabena Aerodrome je et a Haren, Brussels, Belgium.

HOPTON, A. W., sales manager, tires, Dominion Rubber Co., Kitchener, Ont., Canada.

HURLEY, J. C., division manager, Lincoln Engineering Co., St. Louis, Mo.

JONES, OSCAR TREVOR, chief engineer, Vacuum Oil Co., Ltd., London, England.

JORIS, JOSEPH, technical assistant manager, Standard-Vacuum Oil Co. of Jugoslavia Inc., Zagreb, Jugoslavia.

KINTZ, JAMES R., The Buda Co., Harvey, Ill.

LOOMIS, R. C., aviation cadet, Naval Air Station, Pensacola, Florida.

MCNEIL, GORDON I., engineer, Goodyear Tire & Rubber Co., Akron, Ohio.

NEELY, GEORGE LEONARD, research engineer, lubrication research, Standard Oil Co. of Cal., Richmond, Cal.

NOLAN, JOSEPH L., assistant manager, Oil Department, Farmers Union Central Exchange Inc., St. Paul, Minn.

NORBOM, RAGNAR A., engineer, Motor Terminals Co., New York City.

NORTHCOTT, HAROLD JAMES, O.B.E., managing director, Northcott, Williams & Co., Ltd., London, S. W. 1, England.

PALMER, CHESTER U., director motor equipment, City of New York, Department of Sanitation, New York City.

RICE, E. M., regional manager, Chrysler Corp., New York City.

RUTLAND, GUY W., JR., vice-president and manager, The Motor Convoy Inc., Atlanta, Ga.

SMITH, LIEUTENANT FRANK M., Stout Engineering Laboratories, Dearborn, Mich.

SMYTHE, CHARLES M., inspector of petroleum, E. W. Saybolt & Co., New York City.

TAYLOR, CHARLES S., 2nd, laboratory assistant, Riegel Paper Corp., Milford, N. J.

TAYLOR, WILLIAM H., long distance hauling, Sheffield Farms Inc., New York City.

TERRILL, F. O., chief of Transportation and Warehousing Department, Kroger Grocery & Baking Co., Cincinnati, Ohio.

WEBB, PAUL W., associate editor, The Chek-Chart Corporation, Chicago, Ill.

YAMAMOTO, TAKAAKI, engineer designer, Mitsubishi Shoji Kaisha, 120 Broadway, New York City.

"It Helps Us," SAYS

H. F. Fritch, President, Boston & Maine Transportation Co.

"THE S.A.E. papers on practical and technical subjects and on research help us to be forward-looking in a young business which is working out its important place in the transportation picture"

Transportation in Massachusetts has felt Mr. Fritch's influence since 1924, when he began a series of traffic studies for the Boston & Maine Railroad. As passenger traffic manager for the railroad and president of its road-transport subsidiary, he has had a large part in the B.&M.'s pioneering in the highway field. As a member of the S.A.E. (since 1929) he has contributed important papers on transportation to the Society.

THIS PAGE IS PRINTED FOR THE INSPIRATION OF OUR PRESENT MEMBERS—FOR PRESENTATION TO PROSPECTIVE MEMBERS

News of the Society

Sections Present New Lineup of Officers For 1935-1936 Season

● Baltimore

Chairman: Norton L. Dods, executive secretary, Automotive Trades Alliance; vice-chairman: John C. Cahill, branch manager, Brockway Motor Co., Inc.; treasurer: Robert C. Hall, engineering aide, United Railways & Electric Co.; secretary: Louis W. Shank, field engineer, Ethyl Gasoline Corp.

Norton L. Dods
Baltimore

E. V. Schaal
Buffalo

● Buffalo

Chairman: Earl V. Schaal, engineer, Trico Products Corp.; vice-chairman: Louis R. Jones, chassis engineer, Pierce-Arrow Motor Car Co.; secretary - treasurer: Carl W. Georgi, chief chemist, Enterprise Oil Co., Inc.

● Canadian

Chairman: Neil Petersen, general manager, Canadian Acme Screw & Gear Co., Ltd.; vice-chairman: Max Evans, assistant chief engineer, General Motors of Canada, Ltd.; treasurer: Marcus L. Brown, Jr., factory manager, Seiberling Rubber Co. of Canada, Ltd.; secretary: Warren B. Hastings, editor and manager, *Canadian Motorist*.

W. K. Creson
Indiana

● Chicago

Chairman: Robert T. Hendrickson, treasurer, sales manager, Hendrickson Motor Truck Co.; vice-chairman: Fred. L. Faulkner, manager, automotive department, Armour & Co.; treasurer: Harry F. Bryan, engineer, carburetor division, International Harvester Co.; secretary: A. Vance Howe, assistant district manager, Bendix-Westinghouse Automotive Air Brake Co.

N. P. Petersen
Canadian

R. T. Hendrickson
Chicago

● Cleveland

Chairman: A. T. Colwell, director of engineering, Thompson Products, Inc.; vice-chairman: W. C. Brown, illuminating engineer, General Electric Co., incandescent lamp department; vice-chairman: R. W. Brown, research engineer, Firestone Tire & Rubber Co.; treasurer: H. E. Simi, chief engineer, Twin Coach Co.; secretary: A. O. Willoy, assistant professor, Case School of Applied Science.

A. T. Colwell
Cleveland

● Dayton

Chairman: K. H. Glanton, vice-president, charge of mechanical sales division, Dayton Rubber Mfg. Co.; vice-chairman: Z. C. Bradford, mechanical engineer, Delco Products Corp.; treasurer: E. S. Patch, vice-president, Moraine Products Division, General Motors Corp.; secretary: Mearick Funkhouser, engineering department, Delco Products Corp.

K. H. Glanton
Dayton

● Detroit

Chairman: Peter Altman, director, aeronautic department, University of Detroit; vice-chairman representing Passenger-Car Activity: H. T. Youngren, chief engineer, Olds Motor Works; vice-chairman, representing Body Activity: A. J. Neerken, body engineer, Hupp Motor Car Corp.; vice-chairman, representing Aeronautic Activity: L. A. Majneri, chief engineer, Warner Aircraft Corp.; vice-chairman, representing Production Activity: V. P. Rumely, division superintendent, Hudson Motor Car Co.; vice-chairman, representing Student Activity: R. N. Janeway, research engineer, Chrysler Corp.; treasurer: F. W. Marschner, western sales manager, New Departure Mfg. Co.; secretary: R. J. Waterbury, body engineer, Chevrolet Motor Co.

● Indiana

Chairman: W. K. Creson, chief engineer, Ross Gear & Tool Co.; first vice-chairman: J. H. McDuffee, vice-president, general manager, Prest-O-Lite Storage Battery Corp.; second vice-chairman: Daniel C. Teetor, charge of manufacturing, Perfect Circle Co.; third vice-chairman—

J. F. Winchester
Metropolitan

Ex officio: A. W. S. Herrington, president, Marmon-Herrington Co.; treasurer: Robert C. Wallace, assistant chief engineer, Marmon-Herrington Co.; secretary: Harlow Hyde, Indianapolis.

● Metropolitan

Chairman: J. F. Winchester, manager, automotive department, Standard Oil Co. of N. J.; vice-chairman: O. P. Liebreich, power brake

P. R. Wheeler
Washington

engineer, Smith & Gregory of New York, Inc.; vice-chairman for Aeronautics: Charles Froesch, charge, surplus equipment sales, North American Aviation, Inc.; vice-chairman for Transportation and Maintenance: George E. Gray, manager, automotive department, Shell Eastern Petroleum Products, Inc.; treasurer: E. C. Blackman, sales engineer, Thermoid Rubber Co.; secretary: L. M. Porter, assistant professor machine design, New York University.

● Milwaukee

Chairman: C. M. Eason, secretary-treasurer, Fawick Mfg. Co.; vice-chairman: Arthur W. Pope, Jr., research engineer, Waukesha Motor Co.; treasurer: Robert W. Wilson, vice-president, Perfex Radiator Co.; secretary: George W. Curtis, district manager, Timken Roller Bearing Co.

● New England

Chairman: John Q. Adams, manager, Four Wheel Drive Sales Co.; vice-chairman: E. Philip Finn, Bonded Oil System, Inc.; treasurer: Albert Lodge, district manager, Goodrich Oil Products Co. of Massachusetts; secretary: William M. Clark, superintendent transportation equipment, S. S. Pierce Co.

● Northern California

Chairman: J. F. Long, owner, J. F. Long Co.; vice-chairman: A. G. Marshall, assistant superintendent, Martinez Refinery, Shell Oil Co.; treasurer: U. A. Patchett, assistant professor, mechanical engineering, Stanford University; secretary: W. S. Crowell, insurance adjuster, San Francisco.

● Northwest

Chairman: James H. Frink, Washington Iron Works; vice-chairman: George E. Bock, mechanical engineer, Seattle; treasurer: W. W. Churchill, superintendent of equipment, Washington Motor Coach System; secretary: George S. Allin, chief engineer, Truck and Tractor Division, Isaacson Iron Works.

● Oregon

Chairman: J. Verne Savage, shop superintendent, City of Portland, Municipal Shop; vice-chairman: W. H. Paul, instructor, mechanical engineering, Oregon State College; treasurer: O. A. Struss, assistant service manager, Fields Motor Car Co.; secretary: Harley W. Drake, superintendent of garage, Portland Gas & Coke Co.

● Philadelphia

Chairman: J. C. Geniesse, research engineer, Atlantic Refining Co.; vice-chairman: L. M. De Turk, experimental and development engineer, J. G. Brill Co.; treasurer: Delmar D. Robertson, chief engineer, Wilkening Mfg. Co.; secretary: Don Blanchard, editor, *Automotive Industries.*

● Pittsburgh

Chairman: F. W. Heisley, manager, Joseph Woodwell Co.; vice-chairman: R. N. Austen, sales manager, Iron City Spring Co., Inc.; treasurer: Ralph Baggaley, Jr., superintendent of equipment, McGrady-Rodgers Co.; secretary: Stephen Johnson, Jr., chief engineer, Bendix-Westinghouse Automotive Air Brake Co.

● Southern California

Chairman: Robert N. Reinhard, automotive engineer, Western Dairy Products, Inc.; vice-chairman: L. J. Grunder, automotive engineer, Richfield Oil Co. of California; secretary-treasurer: W. E. Powelson, master mechanic, Fire Department, Los Angeles County.

● St. Louis

Chairman: George P. Dorris, automotive engineer, St. Louis; vice-chairman: W. R. Brashear, assistant manager, Aviation Department, Shell Petroleum Corp.; treasurer: Robert M. Pease, manager, St. Louis Factory, Axelson Aircraft Engine Co.; secretary: Charles A. Marien, chief engineer, Ramsey Accessories Mfg. Corp.

● Syracuse

Chairman: Rodman S. Reed, chief engineer, Brockway Motor Co., Inc.; vice-chairman: M. P. Whitney, development engineer, Eclipse Machine Co.; treasurer: W. G. Hawley, Syracuse; secretary: David L. Bacon, Diepress Co.

● Washington

Chairman: Philip R. Wheeler, mechanical engineer, U. S. Navy Department, Bureau of Aeronautics; vice-chairman: Major Harold A. Nisley, chief automotive section office, charge of ordnance, U. S. Army, office Chief of Ordnance; treasurer: Clarence S. Bruce, assistant mechanical engineer, National Bureau of Standards; secretary: W. F. Beasley, automotive engineer, U. S. Army, Ordnance Department.

Peter Altman
Detroit

C. M. Eason
Milwaukee

J. Verne Savage
Oregon

J. C. Geniesse
Philadelphia

F. W. Heisley
Pittsburgh

R. N. Reinhard
So. California

George P. Dorris
St. Louis

Robertson—

"Piston Rings and Engines"

● So. California

PISTON rings and their relation to motor operation was the subject of prime importance at the special September meeting of the Southern California Section of the Society, which was preceded by a dinner, attended by more than 200, at the Breakfast Club in Los Angeles.

D. D. Robertson of the Wilkening Manufacturing Co., Philadelphia, was the speaker of the evening. Mr. Robertson's paper stimulated great interest and was presented with speed and dispatch. Proof of his various assertions was demonstrated by lantern slides showing effects of unit pressure of oil rings on oil consumption, effect of various types of oil and pressure rings on oil consumption and blow-by, relationship of oil consumption and blow-by to speed, and unretouched photographs of pistons showing results of ring fouling.

The discussion following the reading of the lecture covered a wide range. An analysis of the questions and answers following the paper brings out the important fact that blow-by is an important factor in the breakdown of rings, pistons and cylinder walls. It is considered the direct factor governing oil consumption.

It was also brought out that some types of engine service require larger piston clearance than others, and for the purpose of forestalling engine blow-by in such cases, it is essential that the types of rings employed be such as to allow only the requisite amount of lubricating the walls of the cylinder need, and yet be

Section Early Birds

—Sing to Big Audiences

Three Pacific Coast Sections of the Society —Oregon, Northern California and Southern California—got off to an early start in the S.A.E. 1935-1936 season with September meetings, all of which drew unusual attendance. No other September meetings were scheduled by other Sections of the Society, except in the case of the Cleveland Section, which cooperated in the arrangements for the National Production Meeting of the Society, and the Metropolitan Section, which arranged a September Frolic for the 20th of the month. Reports of all these meetings appear in this issue of the S.A.E. JOURNAL.

such as will prevent blow-by which will result inevitably in dilution of the lubricant and eventual fouling and excessive wear of the pistons, valves and bearings.

Some of the highlights of the discussion following Mr. Robertson's paper are as follows:

Q. C. V. ELLIOTT:

Did you ever run a piston without any rings at all?

A. MR. ROBERTSON: No, in my opinion such a test would be impractical under present conditions, as it probably wouldn't run very long.

E. Favary, however, stated that he had confidential information of piston design which would permit the cooling of the piston to the same temperature as the cylinder which might permit the use of a piston without rings in an internal combustion engine.

Q. FRANK T. ELLIOT: It is necessary to replace rings in cylinders whenever they have been removed, due to some operation in a motor overhaul?

A. The best practice is to do so; however, when the ring is in good shape and the cylinder bore has not been worked on, the rings may be replaced, but it takes much longer for the old ring to reseat itself and good performance to be obtained. When the cylinder has been rebored, the walls should be bored and special rings installed. The use of a good expanded ring is desirable.

Mr. Hewitt observed that when the cylinder head of a motor which had been idling at a slow speed for some time was immediately removed, a small pool of unburned gasoline would be found on the top of the piston. This gasoline naturally would wash the cylinder walls, causing improper lubrication of the rings and walls, resulting in undue wear. He added that fleet owners would find it worth while to instruct the drivers not to idle motors at slow speeds.

Q. RALPH GUNDERSON: What is the advantage or disadvantage of doweling the ring into position?

A. It has been reported that this procedure is very satisfactory in that the ring is held in position and consequently does not have to reseat itself if it should change position.

Q. C. V. ELLIOTT: Would blow-by ever be considered an asset in an engine, in regard to oil consumption?

A. If an engine had a great number of miles on it and the rings were in a worn condition, blow-by might be of advantage in keeping the oil from pumping into the compression chamber and valves; however, such a condition would result in dilution.

Q. W. I. HODGE: Has the acceleration and deceleration of a motor in traffic any bearing on ring and cylinder wear?

A. Traffic conditions do govern motor wear to a much greater extent than most people realize.

Q. C. H. JACOBSEN: Is there any advantage in using a step cut, or angle cut ring over square cut ring?

A. No. I am strongly of the opinion that the small amount of blow-by permitted by any square cut ring is negligible, since the area is proportionately very small to the circumference of the piston ring.

Q. W. E. POWELSON: Will you discuss the relative merits in the various methods of finishing the cylinder bore from the standpoint of the maintenance man?

A. I doubt that it would be possible for the average shop to get too fine a finish on the cylinder wall. It is well to hone the walls after the rebore and then to scour with a brush the walls of the cylinder to remove excess abrasives, etc. Washing of the walls after this will be an added precaution.

Q. MR. POWELSON: Is there a yardstick by which the maintenance man could specify the degree of finish in the cylinder bore?

A. There is a machine which was developed at Ann Arbor, Mich., called the Perphelograph, which will determine the degree of finish, but it is considered impractical for the average maintenance shop.

Q. R. N. REINHARD: Is there any standard set to decide whether a rebore and ring replacement job is necessary?

A. No, there are too many factors involved to set any standard.

Q. WALLACE LINVILLE: Do soft spots in cylinder walls appreciably affect piston ring efficiency?

A. Soft spots in the cylinder walls are not of the consequence that some think, as the piston speed is so high that the rings do not deform and enter the low spots.

Q. MR. BRADSHAW: What is the effect of drilling as against the slotting of piston rings?

A. Drilling is the best method allowing closer piston ring fits and permitting more even ring expansion.

The meeting was formally opened by an appeal by Chairman R. N. Reinhard to all present to participate in a friendly cooperative relationship not in groups but as a whole, during the coming year. He further suggested that the body get together informally more often. Amplifying this, he called upon Mr. Powelson to explain a plan that the executive committee had to further this. Mr. Powelson then told the members that it is planned to have an outing at the Arden Dairy Farm, in El Monte, which had been postponed to make way for this special session, on Saturday, Sept. 20, at which they could get together informally and become better acquainted. There will be games, high-jinks, and a bar-b-que dinner at this affair, and the program is complete in every detail.

The newly appointed chairmen of the various committees were introduced: F. C. Patton, Papers; C. H. Jacobsen, Membership; Carl Abell, Publicity; W. I. Hodge, Reception; C. F. Lienesch, Engineering Qualifications. It was stated at this time that never before has the Section had such opportunities for advancement; emphasis of this was the diversity of the types of firms represented at the session.

Some of the organizations having a group of members in attendance are listed here: Pelton Motors, Los Angeles Railway, Judson Motor Chemical Products, Processing Company, Gaton Motor Products, Motor Rim and Wheel, P. & W. Parts, Commercial Motor Parts, Lambert Sales, Frazier Wright, and Union Oil.

At this time Mr. Allen of the Motor Vehicle Engineering Department was called upon for a few words, and he in turn introduced members of that organization. Mr. Mountain of the Automotive Council in turn suitably responded. Earl Cooper, one of the early racing drivers, was introduced, and Field Laboratory members were welcomed also.

Fred Northrup Burlew, who was killed in an airplane accident Sept. 1, 1935 at Glendale, was paid tribute when the group arose in accord to do honor to his memory. Mr. Burlew's reservation for the dinner and meeting, which had been mailed the day before he was killed, was received by the Secretary shortly afterwards.

After the discussion of Mr. Robertson's paper the meeting was adjourned, but informal group discussions continued.

Successful

Safety Meeting

Opens Season

● Oregon

With Fred L. Dennis, director of Highway Safety, Bendix Products Corp., as the featured speaker and with several Portland officials present, the Oregon Section held a "Safety Meeting" on Sept. 13 which drew an attendance of 114 members and guests. J. Verne Savage, Chairman of the Section, presided at the dinner preceding the meeting and at the session itself.

Seated at the speakers' table as guests of the Section were: Judge D. E. Long, Municipal Court, City of Portland; Senator Douglas McKay, president, Oregon Automotive Dealers Association; Reginald Ott, president, Portland Wholesalers Association; J. H. Cassell, manager, Portland Auto Trades Association; Ralph Staehli, manager, Allied Truck Owners Association; Edwin Brown, manager, National Safety Council, Oregon and Columbia Basin Division; John Crittenden, membership manager, Oregon State Motor Association.

Judge Long and Mayor Joseph Carson told briefly of the educational and corrective work being done by his department to make Oregon Traffic more safe for drivers and pedestrians. Several out-of-town visitors were present at the meeting. They were: A. S. Morsman, western district manager, Federal Motor Truck Co., Detroit; H. A. Roberts, technical service representative, Bendix Products Corp., South Bend; G. B. Bassett, west coast manager, Weaver Mfg. Co., San Francisco; F. E. Williams, sales manager, Zenith Carburetor Co., Detroit; C. W. Richards, district representative, Russell Mfg. Co., Middletown, Conn. and R. W. Conroy, manager, Pacific Coast district, Russell Mfg. Co., San Francisco.

Safety literature of several types was distributed through the courtesy of M. E. Vandewater of the Refining Industries and John Crittenden of the Oregon State Motor Association.

Secretary Harley Drake made several announcements about the Student work of the Society including the fact that the S.A.E. Student Branch at Oregon College had been approved by the president of the College and would hold its first formal meeting on Oct. 3. In his address on safety Mr. Dennis emphasized the fact that law enforcement authorities and private citizens must unite in a determined and sustained drive for a fitting punishment of all offenders against traffic laws.

The driver himself, he said, must be taught that "Reaction time is important." It takes the average driver three quarters of a second to move his foot to the brake pedal. This is a reaction time, he brought out. A car running at 60 m.p.h. is moving at the rate of 88 feet per second so that the time interval represented by the driver's reaction allows the car to travel 66 ft. Such distances, Mr. Dennis believes, should be added to the usual tables showing stopping distance in feet at various speeds.

Piston Rings and Cylinder Wear Topics of Live Discussion Twice

● No. California

D. D. ROBERTSON, chief engineer, Wilkening Manufacturing Co., Philadelphia, repeated at the Sept. 10 meeting of the Northern California Section his paper on "Piston Rings and Their Relation to Motor Operation" which had been given Sept. 6 at the Southern California meeting in Los Angeles. As at Los Angeles, the paper aroused considerable discussion.

George Becker, research engineer, Associated Oil Co., offered some brief remarks on road dynamometer testing of piston rings particularly stressing lubrication problems during the starting and warm-up period. He mentioned also corrosive effects and their influence on the operation of valve guides.

S. B. Shaw, automotive engineer, Pacific Gas & Electric Co., was interested in discussing ring pressure and its relationship to increased wear of cylinder walls. He mentioned the high compression in modern engines and the use of spring inserts for piston rings. In answer to a question by him on the effect of the width of piston rings with respect to oil pumping, Mr. Robertson answered that there is a trend toward narrowing of the piston ring which does not in itself bring increased ring wear. Another factor which must be taken into consideration is the higher operating temperature of the piston. The smaller rings give a greater cooling capacity as there is more contact with the cylinder wall.

John MacGregor, Standard Oil Co. of California, brought up the question of the relation of oil consumption to engine speed.

In answer to a question by Professor Domonoske of Stanford University, Mr. Robertson said that recent dust storms in the middle-west had shown that more provision must be made for preventing foreign matter getting into the crankcase oil. Other questions by E. N. Klemgard, Shell Oil Co., Ralph Heintz of Heintz & Kaufman, and Professor Elliot Reid of Stanford University, brought out a varied discussion during which the point was made that piston expanders helped prevent blow-by at high engine speeds and tended to damp out piston vibrations.

The meeting was preceded by a dinner with the attendance of 92 which grew to 138 at the technical session.

E. C. Wood, past-chairman of the Section presided at the meeting. George H. Mosel, past-chairman, gave a brief talk on the features of San Francisco Day at the San Diego Exposition. Color photographs of the Exposition were shown with explanatory comments by H. T. Huggin, Standard Oil Co. of California.

J. F. Long, incoming chairman of the Section, announced the appointment of the Committee Chairmen as follows: Harry Laufer, Membership Committee; E. N. Klemgard, East Bay Meetings; Reception and Attendance, J. F. Long, East Bay; G. H. Mosel, San Francisco; Robert Martland, Publicity; university students, Arthur Domonoske, Stanford Unit; Carl J. Vogt, California Unit; John R. MacGregor, Placement; George H. Mosel, Program; Alfred G. Marshall, Pacific Coast Regional Meeting.

Report of Subcommittee on Motor-Vehicle Design Standards

FOLLOWING presentation of two progress reports in the form of papers by F. L. Faulkner[1], chairman, the Subcommittee on Motor-Vehicle Design of the Transportation and Maintenance Activity, met June 16 at White Sulphur Springs and presented to the Standards Committee 18 recommendations covering components of commercial vehicle design to which the standards procedure of the Society might be applied.

At this meeting, the Committee discussed and reviewed the subjects presented in Mr. Faulkner's papers which had presented in detail a consideration of what commercial vehicle parts might be standardized to simplify the problems of operation and maintenance. The 18 items for which definite recommendations were reached by the Committee were as follows:

	Standardization Recommended
Oil Fill Location	Left side of engine
Oil Gauge Location	Left side of engine
Oil Fill Pipe Size	2 in. minimum
Crankcase Drain Plug	¾ by 14 in. pipe thread, plug recessed for ½ in. square-head wrench
Gasoline Tank Location	Inside cab
Gasoline Tank Fill Opening	External, recessed, and set at angle, or accessible through opening cab door
Gasoline Tank Cap	Quick action type
Gasoline Tank Drain	Located to drain without interference—constructed with opening flush inside tank
Radiator Fill	So designed to permit filling without raising engine hood
Radiator Cap	Quick action type
Radiator Drain	Located left side engine to permit draining without interference. Size ⅜ in. needle seat type
Radiator Mounting	Flexible
Transmission Fill Location	At full lubricant level, either right or left side
Transmission Fill Opening	Minimum ¾ in. diameter
Transmission Drain Opening	Minimum ¾ in. diameter
Transmission Drain Plug	Size ¾ in. diameter, countersunk type for ½ in. square-head type wrench
Rear Axle Fill Opening	¾ in. diameter
Rear Axle Drain Plug	¾ in. by 14 in. pipe thread, countersunk for ½ in. squarehead wrench

Cab sizes and dimensions were discussed but no conclusion was reached and the matter was held open for further study. K. D. Smith, Goodrich Rubber Co., was requested to investigate the subject of valve stem and rim size problems.

Ignition equipment, storage batteries, starters, generators and trailer coupling heights were discussed and it was agreed that after an investigation by the Committee, a review of these subjects would be presented at the Transportation Meeting in October. Merrill C. Horine was assigned to carry on studies of trailer couplings and L. E. Lighton to develop necessary information in connection with the storage batteries and generator problem. F. L. Sage was requested to develop data in connection with ignition equipment standards.

Members of the Subcommittee are: F. L. Faulkner, Chairman, Armour & Co.; B. B. Bachman, Autocar Co.; C. J. Bock, General Motors Truck Corp.; Clinton Brettell, R. H. Macy & Co.; L. R. Buckendale, Timken-Detroit Axle Co.; C. F. Gilchrist, Electric Auto-Lite Co.; M. C. Horine, International Motor Co.; S. Johnson, Jr., Bendix Westinghouse Automotive Air Brake Co.; L. E. Lighton, Electric Storage Battery Co.; T. L. Preble, Tide Water Oil Co.; C. A. Peirce, Diamond T Motor Car Co.; W. D. Reese, International Harvester Co.; Dale Roeder, Ford Motor Co.; F. L. Sage, Dodge Bros Corp. Div. Chrysler Motors; A. J. Scaife, White Motor Co.; K. D. Smith, B. F. Goodrich Rubber Co.; R. B. Wuerfel, Chevrolet Motor Co.; O. B. Zimmerman, Johnson & Co.

[1] Part 1 presented at the Semi-Annual Meeting of the Society, Saranac Inn, June, 1934, published in the September, 1934, issue S.A.E. JOURNAL. Part 2 presented at the Annual Meeting of the Society, Detroit, January, 1935, published in the April, 1935, issue S.A.E. JOURNAL.

Help Design Navy Plane

(*Continued from page 27*)

who worked on this new two-place biplane which is convertible into a landplane or a seaplane include Lieut. Commander J. B. Kneip, chief engineer; G. P. Toews, engine laboratory test; J. F. Hardecker, specification engineer; R. H. Randall, engine project engineer; J. S. Kean, physical test; C. A. Capellino, draftsman and R. P. Fernsler, draftsman.

Quantity production of this new type of plane will depend on the result of its trials. If these are successful, the Navy Department will furnish these planes for use in its student training program.

Otto Mueller is connected with the E. W. Bliss Co. as engineer on special assignment at the plant of the Toledo Machine & Tool Co.

Powers A. Wickes, formerly with the Willamette Hyster Co., has joined the Caterpillar Tractor Co. as logging sales engineer in the Northwest.

J. W. Mills, having resigned as manager of the Sunbeam Motor Car Co., Ltd., may now be addressed at Castlecroft House, Wolverhampton, England.

J. H. Pennington has been transferred from Christchurch to Dunedin, New Zealand, as fuel and lubricating engineer for the Vacuum Oil Co. Pty., Ltd.

Alan Huet Leamy

Alan Huet Leamy, a member of the Society since 1928, and formerly body designer for the Auburn Automobile Co., died recently in Detroit.

Fred Northrop Burlew

Fred Northrop Burlew, a recent graduate of the Massachusetts Institute of Technology and Leland Stanford University, was killed in an airplane accident on Sept. 1. A member of the Society for only a few months, he was affiliated with the Southern California Section.

Meetings Calendar

Transportation Meeting
Oct. 10
Palmer House, Chicago

Tractor and Industrial Power Meeting
Oct. 11 & 12
Palmer House, Chicago

Regional Transportation Meeting
Oct. 29—Nov. 1
Newark, N. J.
(Sponsored by Metropolitan Section, S.A.E. and other organizations)

S.A.E. Annual Dinner
Nov. 4
Hotel Commodore, New York City

S.A.E. Annual Meeting
Jan. 13-17, 1936
Book-Cadillac Hotel, Detroit

S.A.E. Pacific Regional Meeting
Nov. 18 & 19
San Francisco, Calif.
(Under auspices of Pacific Coast Sections)

Baltimore—Oct. 8

Where De We Go from Here?—William B. Stout, president, Stout Engineering Laboratories, Inc., and president of the S.A.E. Conquering the World with Automotive Engineering—John A. C. Warner, general manager, S.A.E.

Buffalo—Oct. 8

Hotel Statler; dinner 6:30 P. M. Research in the Automotive Industry—T. A. Boyd, head of Fuel Section, Research Division, General Motors Corp.

Canadian—Oct. 16

Royal York Hotel, Toronto; dinner 7:00 P. M. Where Do We Go from Here?—William B. Stout, president, Stout Engineering Laboratories, Inc., and president of the S.A.E.

John A. C. Warner, general manager, S.A.E.

Chicago—Oct. 10

Palmer House. Participation in Transportation and Maintenance Meeting of the Society.

2:00 P. M. Overloading of Tires and Economical Consideration Involved—James E. Hale, manager, Development Dept., Firestone Tire & Rubber Co. (Discussion by B. J. Lemon, engineer, U. S. Rubber Products, Inc.)

8:00 P. M. Economical Loading of Motor Trucks—Arthur J. Scaife, consulting field engineer, White Motor Co. (Discussion by Eric W. Lager, manager, Automotive Dept., Swift & Co.; Harry O. Mathews, superintendent of motor equipment, Illinois Bell Telephone Co., and others.)

Cleveland—Oct. 14

Motor Fuels—Earl Bartholomew, director, Engineering Laboratory, Ethyl Gasoline Corp.

Detroit—Oct. 21

Book-Cadillac Hotel; dinner 6:30 P. M. Passenger-Car Meeting.

Indiana—Oct. 10

Athenaeum; dinner 6:30 P. M. Transportation Problems of the U. S. Marine Corps—Capt. K. Inman, U. S. Marine Corps.

Metropolitan—Oct. 14

The Roger Smith, 40 E. 41st St., New York City; dinner 6:30 P. M. Engineering Status of the Light Private Airplane—John H. Geisse, chief, Development Section, Bureau of Air Commerce. Toastmaster—E. P. Warner, editor, *Aviation.*

Milwaukee—Oct. 7

Milwaukee Athletic Club; dinner 6:30 P. M. Subject: Automotive and Industrial Applications of Anti-Friction Bearings.

New England—Oct. 8

Walker Memorial, Massachusetts Institute of Technology; dinner 6:30 P. M.

Diesel Meeting.

Northern California—Oct. 8

Athens Athletic Club, San Francisco; dinner 6:30 P. M. Subject—Diesels. Prof. Carl Vogt, University of California, will be chairman of the meeting.

Oregon—Oct. 16

Multnomah Hotel, Portland; dinner 6:30 P. M. Engine Efficiency—Mr. Bartlett, engineer, McQuay-Norris Mfg. Co. There will be a display of the teardrop design car.

Philadelphia—Oct. 9

Inquirer Bldg.; dinner 6:30 P. M. Where Do We Go from Here?—William B. Stout, president, Stout Engineering Laboratories, Inc., and president of the S.A.E. Address by John A. C. Warner, general manager, S.A.E.

Pittsburgh—Oct. 17

Motor Conditions Affecting Piston Ring Performance—Ralph R. Teetor, in charge of engineering, Perfect Circle Co.

Southern California—Oct. 11

Mona Lisa Restaurant, 3343 Wilshire Blvd., Los Angeles; dinner 6:30 P. M. An Analysis of Automobile Steering Geometry—Frank N. Bonta.

Syracuse—No Meeting

Washington—Oct. 7

Engineers Club, Washington, D. C.; dinner 6:30 P. M. Where Do We Go from Here?—William B. Stout, president, Stout Engineering Laboratories, Inc., and president of the S.A.E. Conquering the World with Automotive Engineering—John A. C. Warner, general manager, S.A.E.

Student Meetings

Oct. 3—Organization Meeting. S.A.E. Student Branch at Oregon State College.

Oct. 14—Book-Cadillac Hotel, Detroit. Student Activities Meeting.

Papers from Recent Meetings in Digest

HERE are digests of papers presented at recent Meetings of the Society.

* * * *

Some of these papers will be printed in full in the S.A.E. JOURNAL.

Mimeographed copies of *all of them* will be available, until current supplies are exhausted, at a cost of 25 cents per copy to members; and at 50 cents per copy to non-members. Orders for mimeographed copies must be accompanied by remittance and should be addressed to Sessions Secretary, Society of Automotive Engineers, 29 West 39th St., New York.

Milwaukee Section Paper

Wednesday, May 1

Development of Electric Cast-Iron—*D. Porter Spencer, metallurgist, Belle City Malleable Iron Co.*

THE two basic conditions which have been found to control the production of high-strength cast-iron are: first, that carbon should be lower than obtained in cast iron produced by conventional methods and, second, that carbon must be present as very fine evenly distributed graphite. The electric furnace operates without the use of either solid or gaseous fuel; hence, the danger of contamination from carbon, sulphur, and other non-metallic elements is averted. Furthermore, the very nature of the furnace permits of closer control of the elements through the taking of preliminary samples for analysis and the making of adjustments to the bath when necessary.

The engineering properties being regularly obtained with electric irons in the as-cast condition without alloys are stated. Electric iron is essentially an engineering material or specification iron. Not only is it possible to produce an iron to meet the specific need, but a duplication of results is an attribute of this process.

Electric irons ordinarily are heat treated to bring about either or both of two distinct changes: first, dimensional or mechanical changes of the specimen, and second, physical changes in the property of the metal itself. Under mechanical changes the casting may be heated to change its dimension or to insure a fixed dimension after machining by eliminating growth, at least partially. More important is the thermal process of relieving stresses, for there are many cases where distortion is caused by machining or casting stresses. In conclusion, the outstanding characteristics of electric iron are enumerated.

Milwaukee Section Paper

Wednesday, May 1

Machineability, Engineering Properties and Applications of Electric-Furnace Cast-Iron—*R. J. Anderson, assistant superintendent, Belle City Malleable Iron Co.*

SO many variables enter into the processing of cast iron that to set definite values on its machineability is a very difficult task. The composition, structure and physical properties of cast iron extend over a wide range, dependent upon these factors; cast iron varies from being one of the most readily machineable to being the most unmachineable of ferrous materials. At one extreme we have a completely annealed iron which is the most readily machineable and, at the other, a chilled iron which is practically unmachineable.

Annealed cast-iron machines very easily because the structure consists of an iron containing little or no combined carbon and broken-up by a number of free-carbon flakes. Chilled iron is extremely difficult to machine because its structure is composed chiefly of hard iron-carbides. The Brinell hardness is very closely related to structure, physical properties and machineability. The comparison of Brinell hardness to structure is shown in charts, and these are explained.

A number of other comparative tests, most of which were made in the plants of users of electric-furnace iron and included turning, boring, hobbing and the like, showed very substantial savings in machining costs.

The point the author makes clear regarding machineability is that in all of these tests the results have been consistent. Other tests were made to demonstrate the strength and rigidity of electric-furnace iron, and a statement is made of some of the more important applications for which electric-furnace iron has been used and proved to be superior.

Student Paper

(Auspices Oregon Section)

Saturday, May 4

A Study of the Comparative Values of the Different Methods of Automotive Valve Reconditioning—*E. J. McLaughlin, student, Oregon State College.*

THE purpose of the paper is to consider this problem, not from the designer's viewpoint, but rather to throw some light on the comparative values of the different types of valve-reconditioning jobs available. From the standpoint of the individual passenger-car owner, what type of job is best? From the standpoint of the shop man, how can he turn out the best job obtainable with his present equipment?

The paper answers these questions by consideration of the following points:

(1) Which type of job gives the tightest-fitting valve?

(2) Which type of job gives the best alignment of valve and seat faces with the valve guides?

(3) Which type of job gives the smoothest finish to the valve face?

(4) What effect does each of the three preceding factors have on the operation of the valve?

In making these tests, two Model-A Ford heavy-duty truck engine-blocks, complete with valves and guides, were used. These two blocks were taken to a number of the larger garages, machine shops or whole-

sale automotive-equipment houses in Portland, Ore., each concern reseating or refacing one or two valves. The blocks were shipped to Oregon State College, Corvallis, Ore., for the test.

The construction of the testing equipment is illustrated and described, and the technique observed in making the tests is stated, together with the test procedure. Answers to the specific objectives (1) to (4) are given, and an elaborate presentation of the test data is included.

Production Meeting Papers

Wednesday, September 18

Methods of Finishing Transmission Gears—*S. O. White and M. C. Hedgeland, Warner Gear Co.*

IN the effort to produce quieter gears for automobile transmissions, there has been great progress in recent years. Improved steels, forging and heat-treating methods have played a large part, and new tools for finishing both the green and the hardened gear tooth have come into general use.

Since the more nearly perfect the green gear is, the better are the results after heat treating, various finishing operations are in use to correct errors of cutting, remove transverse cutter-marks and leave a smooth tooth-suface.

Burnishing has long been popular and there are improved methods of doing this. New cutting devices have been developed by several makers, which remove a very small amount of material, taking out transverse cutter-marks and correcting cutting errors, as well as leaving a smooth surface. Several of these methods are described and illustrated.

Although heat-treatment distortion is under much better control than formerly, it is still necessary in many cases to perform a finishing operation on the hardened gear. The general trend is toward some form of lapping, and several of these methods are discussed.

Application of Induction Heating in Automotive Production—*E. L. Bailey, Chrysler Corp.*

INDUCTION heating for industrial processes has long been most attractive to engineers and production men alike. The thought of generating the heat required for a particular thermal process within the part being treated is most alluring, carrying with it visions of high efficiency, rapid heating, controlled atmosphere, and many other secondary advantages.

Induction heating is a process or method by which metal parts are heated by simply placing them in an alternating magnetic field. The action is that of the transformer whereby electrical energy is transferred or passed over to another isolated electric or secondary circuit by means of the magnetic field; thus, no physical attachments or electrical contacts are necessary to have electrical currents which are dissipated as heat, flow in the parts to be processed.

The strength and frequency of the alternating magnetic field can be selected to produce any desired rate of heating and ultimate temperature. A circuit can be set up to dry lacquer at 160 deg. fahr. on thin sheet-metal parts or to melt in record time immense steel ingots.

Induction heating is now commercially applied in automotive production to such processes as:

Melting of metals, both ferrous and non-ferrous alloys of moderate and extremely high melting temperature

Ring-gear expansion for shrinking the gears on to flywheels

Heat treating as in the drawing of hardened-steel parts (laboratory process developed ready for use) and in the surface hardening of crankshafts

Tank heating for chemical processes where the fire hazard is great or rapid heating is necessary

The induction oven for paint baking in which field large production-ovens of the continuous type are used to bake the paint on the wheels, fenders, radiator shells, lamp brackets, head lamps with the glass in place, tire carriers, and all manner of sheet-metal car-parts

Drving automobile parts and even the entire metal bodies after washing off the metal-cleaning materials

Over 600 kw. of inductively heated ovens are in daily use in the automotive industry.

The development of lower cost electrical apparatus suitable for induction heating has greatly stimulated its commercial use, and the field of application will rapidly expand as the many values of the process become better known.

Rustproofing and Paint-Adherence Technique—*F. P. Spruance, American Chemical Paint Co.*

EXTENDING the life of those parts most quickly destroyed by corrosion, an important problem in the automotive industry, for practical purposes resolves itself into preventing the failure of paint on metal surfaces.

The porosity of the paint films permits moisture to get through to the metal, and thus to induce electrolytic rusting. Chemically cleaning before painting retards paint failure. Coating the metal with phosphates gives better protection still, by permitting thicker coats of paint. This phosphate surface is not ductile, though, and breaks when the metal is bent, causing paint failure.

Best protection is obtained by first plating the steel with zinc and then converting this plated surface into a zinc phosphate, so that paint will adhere to it. The next best method is plating steel with a continuous coating of zinc phosphate by means of alternating-current electrolysis.

A chromate treatment known as the Cromodine process has been developed, producing a chromate surface on the steel at a low cost. This coating is as elastic and as ductile as the steel itself; it forms a perfect bond with paint, and is very effective in increasing the life and durability of paint, lacquer, or enamel finishes.

Resistance Welding in the Automotive Industry—*J. A. Weiger, P. R. Mallory & Co., Inc.*

THIS paper outlines the progress made during the last ten years as regards electric-resistance welding in the automotive industry, and shows the trend from simple to semi-automatic and fully automatic machines. Welders are described which make up to 200 welds during one machine-cycle. Machines for producing many welds at one time are described, and the advantages gained thereby are covered in detail.

Various types of resistance welding are covered; namely, spot welding, flash butt-welding, electrical upsetting, seam welding, and projection welding.

The necessity for water cooling and the proper electrode and die material and design are emphasized, and recommendations for the proper water cooling, electrode and die material and design for the various types of electric-resistance welding are explained.

The illustrations shown cover outstanding resistance-welding methods as practised in a number of plants throughout the automotive industry. In practically all cases where the production rate has improved, better welds have also been secured.

Discussion of Annual Meeting Paper

(Passenger Car Session)

January, 1935

Materials and Technique in the Quieting of Automobiles—*J. S. Parkinson, acoustical engineer, Johns-Manville Research Laboratories.*

THE author states that a consideration of engineering acoustics from the standpoint of automotive design requires certain modifications in our ideas. Acoustical phenomena as ordinarily encountered in buildings or in the open are on a much larger scale. The small scale involved in automobile work lessens the importance of reverberation, because the mean free path of the sound between reflections is much shorter and, consequently, the absorption coefficient at reflection is less significant.

When sound is generated within an enclosed space, a tremendously complicated series of reflections takes place. In nearly all noise problems, a number of sounds are present simultaneously. This fact may not be apparent, because those of greater intensity or lower frequency may mask others. But it is rarely that a problem can be solved completely by the elimination of one sound. When the most apparent sound has been removed, another will be heard which was not apparent before.

The terminology of acoustical engineering is in some respects confusing. The decibel scale, based on logarithmic units, is a convenient tool for the initiate, but the novice needs something which corresponds more closely with actual experiences. With this thought in mind, a number of investigators have been attempting to discover the relationships between sound intensities (which are expressed in energy units, as in microwatts per square centimeter of wavefront), sound-intensity levels (which are expressed in decibels above some previously chosen threshold level), and the apparent loudness of a sound as judged by the average human ear. The American Standards Association Committee on Acoustical Measurements has authorized a tentative scale of this type, based on some research done at the Bell Telephone Laboratories, believing that this work most closely agrees with the results of previous investigators. For want of a more particularized name, this scale has been called a "loudness" scale, as differentiated from the decibel scale, to be henceforth known as a scale of "loudness levels".

During the last year the Johns-Manville Corp. has made noise measurements on a number of motor cars. Some of the results are stated in the paper.

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Notes and Reviews

THESE items, which are prepared by the Research Department, give brief descriptions of technical books and articles on automotive subjects. As a rule no attempt is made to give an exhaustive review, the purpose being to indicate what of special interest to the automotive industry has been published.

The letters and numbers in brackets following the titles classify the articles into the following divisions and subdivisions: *Divisions*—A, Aircraft; B, Body; C, Chassis Parts; D, Education; E, Engines; F, Highways; G, Material; H, Miscellaneous; I, Motorboat; J, Motorcoach; K, Motor-Truck; L, Passenger Car; M, Tractor. *Subdivisions*—1, Design and Research; 2, Maintenance and Service; 3, Miscellaneous; 4, Operation; 5, Production; 6, Sales.

AIRCRAFT

Le Dispositif de Pilotage Automatique des Avions, Système Siemens

Published in *Le Génie Civil*, July 20, 1935, p. 65. [A-1]

The automatic piloting system developed by Siemens-Schuckert and recently tested on a Junkers plane consists, first, of detectors designed to indicate such rotations about the three axes of an airplane as are caused by squalls; and second, of servo-motors to manipulate the controls automatically to counteract such rotations.

La Normalisation en Aéronautique

By Pierre Blanchet. Published in *L'Aéronautique*, May, 1935, L'Aérotechnique section, p. 41. [A-1]

Reviewing briefly the present status of standardization in the field of aviation, the author dwells particularly on the development of the so-called standard numbers used in fixing the dimensions of standardized parts and on the progress achieved in tire standardization.

CHASSIS PARTS

Design of Gears for Minimum Noise

By Willis G. Meyers. Published in *Product Engineering*, July, 1935, p. 259. [C-1]

The author analyzes noises in gear drives, classifying them into three characteristic types: (a) a steady growl or hum caused by inaccurate tooth spacing or inaccurate tooth profiles; (b) a pulsating growl emanating in regular cycles, which is usually a sound produced by gear eccentricity; and (c) a high pitched whine resulting from rough tooth surfaces.

The problem is summarized as one of designing and manufacturing gears that will be less susceptible to variations in tooth profile, eccentricity and spacing; in developing manufacturing methods capable of more accurate control of gear dimensions; and in developing gear materials and mountings which will have a damping rather than an amplifying effect on vibrations.

ENGINES

Liquid-Cooled Engines—Design and Application to High-Speed and Other Aircraft

By Captain A. Graham Forsyth. Published in *The Journal of The Royal Aeronautical Society*, June, 1935, p. 449. [E-1]

The author sets forth his views on possible developments and improvements which may be made to increase the power output and to reduce the weight of the engine without reducing the reliability and to improve their installation, thereby providing the aircraft designer with power plants capable of being installed as an integral part of the machine.

A Note on the Petrol Injection Engine

By G. L. Ensor. Published in *The I.A.E. Journal*, June-July, 1935, p. 13. [E-1]

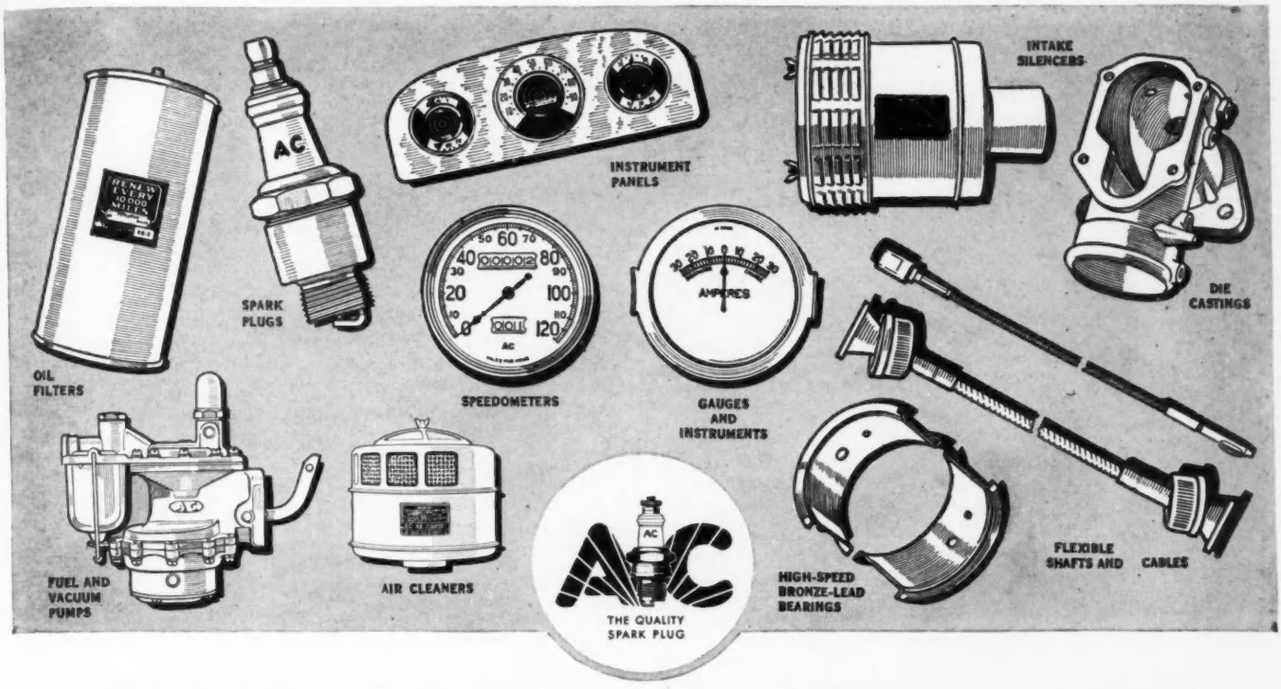
The author, a member of the technical staff of Ricardo and Company, describes the article as a collection of thoughts on a subject of some general interest to the automobile engineer, though mainly concerned with the aircraft engine, and deals with the possibilities rather than the problems of fuel injection.

Balancing of Engines

By A. C. Sampietro. Published in *The I.A.E. Journal*, June-July, 1935, p. 17. [E-1]

The factors affecting the balance of an engine are listed as: (a) varia-

(*Continued on page 40*)



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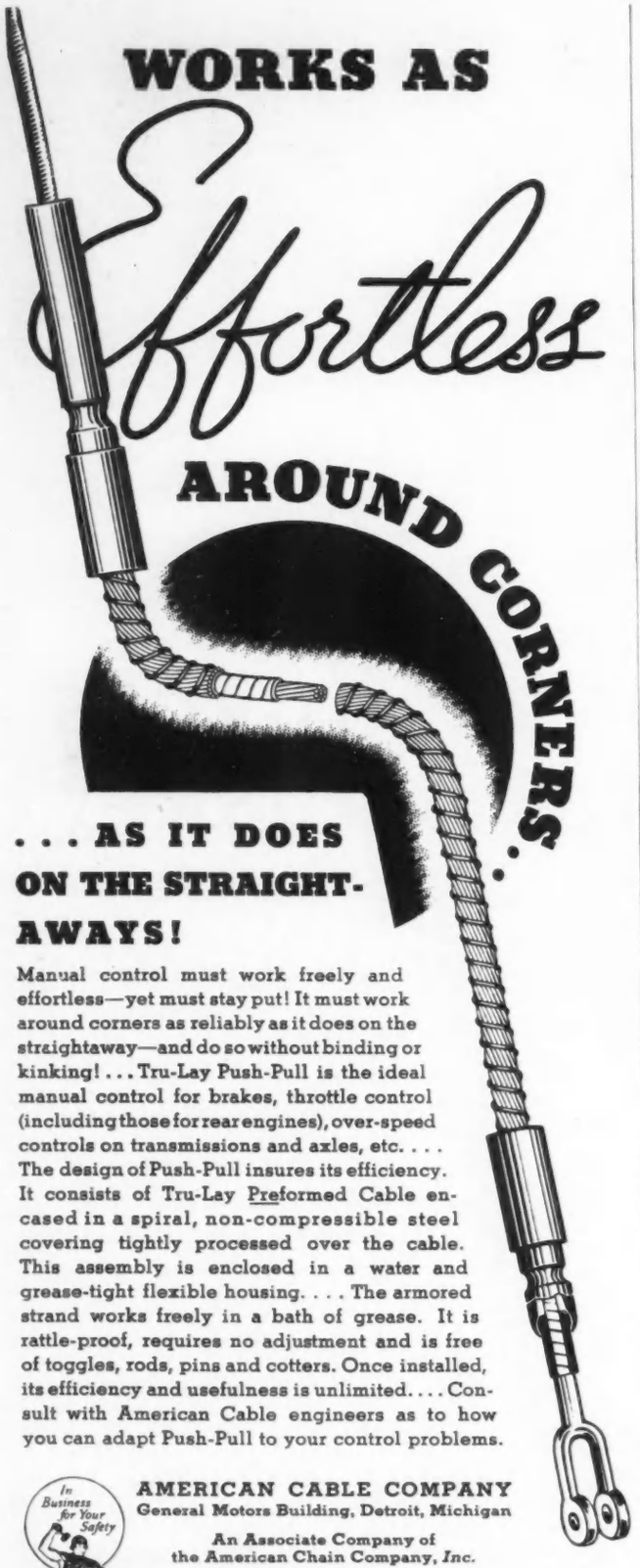

Manual control must work freely and effortless—yet must stay put! It must work around corners as reliably as it does on the straightaway—and do so without binding or kinking! . . . Tru-Lay Push-Pull is the ideal manual control for brakes, throttle control (including those for rear engines), over-speed controls on transmissions and axles, etc. . . . The design of Push-Pull insures its efficiency. It consists of Tru-Lay Preformed Cable encased in a spiral, non-compressible steel covering tightly processed over the cable. This assembly is enclosed in a water and grease-tight flexible housing. . . . The armored strand works freely in a bath of grease. It is rattle-proof, requires no adjustment and is free of toggles, rods, pins and cotters. Once installed, its efficiency and usefulness is unlimited. . . . Consult with American Cable engineers as to how you can adapt Push-Pull to your control problems.

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NOTES AND REVIEWS

Continued

tion of torque, (b) inertia and centrifugal forces, and (c) elastic deformation of parts. The author gives a brief discussion of each factor.

Le Moteur à Charbon Pulvérisé

Published in *La Technique Moderne*, July 15, 1935, p. 490. [E-1]

To what extent can Germany succeed in replacing liquid with solid pulverized fuels for engine use? In attempting to throw light on this subject, this article gives a brief review of the historical, technical and economic aspects of the question, including such topics as design, efficiency, wear and costs.

Experimentelle Beiträge zu dem Dämpfungsproblem des Auspuffschalles an Kraftfahrzeugmotoren

By Herbert Martin. Published in *Automobiltechnische Zeitschrift*, May 25, 1935, p. 243. [E-1]

An account is given of an experimental investigation made at the Dresden engineering college to check the theories of Dr. M. Kluge with regard to the action of exhaust gases in the manifold and muffler and to test the effectiveness of the acoustical filter suggested by him.

Mounting Tapered Roller Bearings to Suit Operating Conditions

By Paul Haager. Published in *Machinery*, July, 1935, p. 658. [E-4]

Mr. Haager discusses the application of tapered roller bearings and cites examples of installations covering a wide range of service.

HIGHWAYS

Proceedings of the Twenty-First Annual Road School

Held at Purdue University—Engineering Bulletin No. 35. Compiled and Edited by Ben H. Petty. Published by Purdue University, Lafayette, Indiana, January, 1935; 177 pp., illustrated. [F-1]

Of particular interest in the Proceedings of the last Annual Road School at Purdue University are the Final Report of the Indiana Traffic Survey, by W. F. Milner, and the paper: Use of Traffic Survey Data in Developing the State Highway System, by John Wheeler.

Report of The Federal Coordinator of Transportation, 1934

Published by the Superintendent of Documents, Government Printing Office, City of Washington, 1935; 245 pp., price twenty cents. [F-3]

The purpose of this report is to submit recommendations for further legislation to improve transportation conditions throughout the country.

In his letter of transmittal the Chairman of The Interstate Commerce Commission, states: "The report of the Coordinator is a clear and authoritative exposition of the transportation situation, based upon wide and thorough research and knowledge, and his findings and conclusions are of great value as aids to an understanding and discussion of the important and difficult public problems with which he deals."

MATERIAL

Stainless in Aircraft

By W. L. Sutton. Published in *Aviation*, June, 1935, p. 30. [G-1]

The structural possibilities of stainless steel are compared with the more familiar light alloys of aluminum. The author's discussion of the properties and uses of stainless steels in aircraft is to be concluded in a second article scheduled to appear in *Aviation* for July.

Appendices to Ferrous Metallurgy in Aeronautics

By W. H. Hatfield. Published in *Aircraft Engineering*, June, 1935, p. 143. [G-1]

The following appendices are part of the paper by Dr. Hatfield which appeared in *Aircraft Engineering*, May issue, and was reviewed in these columns last month: I—Aircraft Steel Specifications; II—Main Engine Parts and Power Transmission.

The Resistance of Spring Steels to Repeated Impact Stresses

By G. A. Hankins and H. R. Mills. Published in *Engineering*, June 7, 1935, p. 611. [G-1]

In previous investigations made at the National Physical Laboratory the fatigue tests employed have consisted of repetitions of cyclic stress without impact. These tests were undertaken to determine the effect of surface conditions on the repeated impact resistance of certain available spring steels.

The following conclusions were reached:

(a) The irregular decarburized surface which is present on a normal heat-treated spring plate produces a low repeated-impact endurance limit in the same manner as it produces a low endurance-fatigue limit;

(*Continued on page* 42)

Don't let inertia encumber your business

BUSINESS philosophy associates "inertia" with the ever-debatable policy of "Let well enough alone." Too often this inertia is the result of a groundless fear of upsetting routine, changing specifications and inspection standards, resetting machines, recasting work sheets, ironing out new processing kinks . . . temporarily slowing up production.

Nevertheless, executive and sales heads ever have before them the vital problems of competition and consumer preference. They see clearly the dangers of inertia. But they are not always technicians. Hence, they must look to you — metallurgist, engineer, production expert — to share the responsibility for Progress in raw material and product.

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"Moly" not only improves ordinary carbon steel, but actually increases other elements' effectiveness for their particular purposes. This has been proved, times beyond record, in the laboratory, foundry, factory and under every manner of punishing service conditions. Greater strength, toughness, shock resistance, less temper embrittlement, easier machinability, and many other improvements are present in Moly steels and irons. Yet, while bettering the product, Moly seldom adds to the ultimate costs — and usually reduces them.

To engineers, metallurgists and production executives we offer these interesting books: "Molybdenum in 1934" and "Molybdenum in Cast Iron — 1934 Supplement." Also ask us to mail you our periodical news-sheet, "The Moly Matrix." Be free, too, to enlist our Detroit experimental laboratory's help at any time. Climax Molybdenum Co., 500 Fifth Ave., New York.

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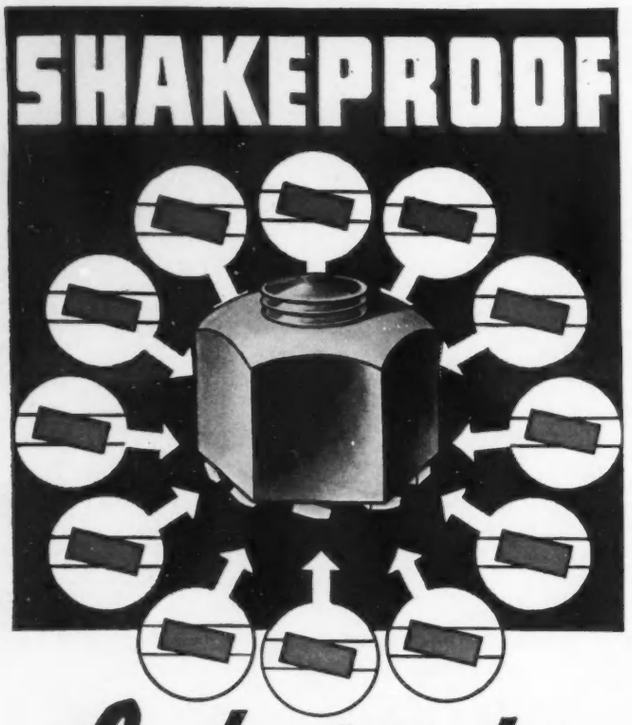

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NOTES AND REVIEWS

Continued

(b) The irregular decarburized surface on a spring steel does not appear to have any adverse effect on the resistance to a large impact of magnitude approaching the full single-blow impact strength of the plate;

(c) The graphite heat treatment, which has been shown to give a high endurance-fatigue limit for spring steels, may also be useful for improved resistance to repeated impact; and

(d) In general, the results show that Stanton and Bairstow's conclusions for notched test-pieces apply to both machined and unmachined spring steels in that the behavior under a very small number of impacts is indicated by the result of a single-blow test, but that repeated-impact endurance limits correspond to the results of cyclic-fatigue endurance tests.

An Investigation of Motor Oils

By Burton J. Robertson. Bulletin of the Engineering Experiment Station No. 10. Published by the University of Minnesota, Minneapolis, March 7, 1935; 47 pp. [G-1]

The investigation reported in this bulletin was undertaken with the following objectives:

(a) To ascertain whether oils delivered by station attendants conform to the Society of Automotive Engineers viscosity numbers specified by purchasers, and whether quality is consistent with price;

(b) To investigate the uniformity of the product marketed from month to month; and

(c) To determine as far as possible the relative merits of automobile engine lubricants sold at retail to the general public.

Composite Factor for Rating Lubricating Oil Quality Greatly Needed

By H. A. Everett. Published in *National Petroleum News*, June 19, 1935, p. 28. [G-1]

In this paper presented before the Twelfth Annual Meeting, Pennsylvania Grade Crude Oil Association, State College, Pa., June 20-24, 1935, Dr. Everett reports the results of a series of crankcase oil tests made in the Mechanical Engineering Laboratory of Pennsylvania State College in cooperation with the Association during the past two years.

Data are given on the initial properties and the important changes in the physical properties of the oils tested after eight hours of usage. These data were obtained on four identical automobile engines being operated under carefully controlled conditions.

Les Progrès de la Métallurgie de l'Aluminium

By Léon Guillet. Published in *Le Génie Civil*, April 20, p. 382; April 27, p. 401; May 4, p. 435, and May 11, 1935, p. 454. [G-1]

In his survey of the progress of aluminum metallurgy, the author covers the topics of ores, production and selling price. The situation in other countries as well as in France is covered.

Les Applications du Caoutchouc dans l'Industrie Automobile

By Pierre Wolff. Published in *Journal de la Société des Ingénieurs de l'Automobile*, February, 1935, p. 96. [G-1]

After discussing briefly the production and properties of rubber, the author examines extensively and in detail its application in automotive manufacture. About 50 different parts are cited in which rubber is used, together with the approximate weight of rubber used in each and methods of its application in various individual makes of car are discussed.

L'Adduction par Pipe-Lines du Pétrole de Mesopotamie aux Ports de la Mediterranée

By Ch. Dantin. Published in *Le Génie Civil*, March 9, 1935, p. 221. [G-1]

The pipe line installation for the transport of crude petroleum from the Mesopotamian fields to the Mediterranean ports is described, the equipment for and methods of installing the pipes, the pipes themselves, the pumping stations and the embarkation port plan being included in the discussion.

The Principles of Motor Fuel Preparation and Application—Volume II

By Alfred W. Nash and Donald A. Howes. Published by John Wiley & Sons, Inc., New York and London, 1935; 523 pp., illustrated. [G-3]

Volume I of this book was reviewed in these columns of the April, 1935, issue.

Volume II deals with the properties of motor fuels and covers such subjects as Analysis, Sulphur Contents, Gumming Properties, Volatility Requirements and Knock Ratings as well as Motor Fuel and Aviation Spirit Specifications and a chapter on Automotive Diesel Engines and Diesel Fuels.

(*Continued on page* 44)

25 OPERATIONS TO FINISH ONE FORD VALVE

EACH Ford valve requires twenty-five separate operations from the time work starts on the rough valve until it is ready for use. That is a surprising number of operations for such a simple-looking part, but typical of the care used in manufacturing all Ford parts.

Ford valves are made in Northville, Michigan, in one of fourteen Ford single-department plants located within fifty miles of the main Ford plant in Dearborn.

The stems of the rough valves first receive two preliminary grinding operations. Then they go through a furnace where the heads are brought to a red heat. Next, automatic fingers place them in a huge machine where a ram strikes the red-hot head. This operation refines the grain structure in the head, straightens it and forms the valve seat.

Valves then pass through other grinding, machining and polishing operations. Each stem is ground five times for greater accuracy and smoothness. Inspection gauges keep a constant check on the precision of the machines.

In spite of this care, each Ford valve is subjected to most rigid final inspection. Amplifying gauges check the stem for roundness within two ten-thousandths of an inch. Similar gauges check diameter.

Other inspection equipment indicates the slightest "run out" of seat and checks the stem end for squareness. Then the valves go into a constant temperature room where they are inspected for length.

While the difference in length of a valve stem under normal temperature changes is very slight, measuring valves in a room where the temperature is controlled indicates the precautions taken in manufacturing Ford parts.

FORD MOTOR COMPANY

Ford

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NOTES AND REVIEWS

Continued

Handbook Butane - Propane Gases

Arranged and Edited by George H. Finley. Published by *Western Gas*, Los Angeles, California, Second Edition, 1935; 375 pp., illustrated. [G-3]

The new edition of the Handbook is designed to treat every major phase of the liquefied petroleum gas industry—physical characteristics of the gases, manufacture, storage, transportation and utilization.

Chapter XII, "The Use of Liquefied Petroleum Gases in Internal Combustion Engines," discusses all engine applications of these fuels—automotive, bus, truck, locomotive, and tractor, with illustrations of utilization equipment.

Reports on the Progress of Naphthology, 1934

Published in the *Journal of the Institution of Petroleum Technologists*, June, 1935, p. 435. [G-3]

Of especial interest in this annual review of progress in naphthology are the following articles:

Motor Benzole, by A. K. Steel;
Automobile and Aero Engines, by L. G. Callingham;
The Oil Engine, by Oliver Thornycroft; and
Petroleum Literature, 1934, by Winifred S. E. Clarke.

MISCELLANEOUS

Report of the National Physical Laboratory for the Year 1934

Published by His Majesty's Stationery Office for the Department of Scientific and Industrial Research, London, 1935; 260 pp., illustrated. [H-1]

The Annual Report of the National Physical Laboratory for the year 1934 is now available, the sections covering the work of the Engineering, Metallurgy and Aerodynamics Departments being of especial interest to the automotive engineer.

Power Plant Testing

By James Ambrose Moyer. Published by McGraw-Hill Book Company, Inc., New York and London, Fourth Edition, 1934; 614 pp., illustrated. [H-1]

This manual of testing steam generating equipment, engines, turbines, pumps, refrigerating machinery, fans, fuels and lubricants has been completely rewritten and enlarged in its fourth edition.

A Quarter of A Century

Published in *The Automobile Engineer*, June, 1935, p. 197. [H-1]

In conjunction with its twenty-fifth anniversary *The Automobile Engineer* has prepared this review of design and development during its life. Progress is recorded under the following heads: engines, carburetion, electrical equipment, clutches, gear boxes, rear axles, front axles, steering, brakes, suspension, chassis, bodywork, commercial vehicles, oil engines, fuels and oils, and workshop practice.

Die Messung der Lautstärke der Fahrgeräusche und Hupen von Kraftfahrzeugen im Hinblick auf die Gesetzlichen Bestimmungen

By A. Reinsch and U. Schmidt. Published in *Automobiltechnische Zeitschrift*, July 10, 1935, p. 321. [H-1]

A legal limitation on the permissible loudness of general automobile noise and of automobile horns became effective in Germany in the spring of this year. The methods for determining whether or not this legal limit is exceeded and a new noise measuring instrument are described.

The Engineer and His Societies

By Huber O. Croft. Published in *Mechanical Engineering*, July, 1935, p. 431. [H-3]

The author looks into the organization of engineering societies, and reviews graphically the development of twenty of the ninety or more existing national engineering societies. Organization in the engineering field is compared with that in the medical and legal professions and coordination of existing societies rather than formation of additional new ones is strongly urged.

PASSENGER CAR

Untersuchungen über die Steigfähigkeit von Fahrzeugen

By W. Kamm and L. Huber. Published in *Automobiltechnische Zeitschrift*, May 25, 1935, p 253. [L-1]

Road traction of vehicles in grade climbing was investigated at the Stuttgart engineering college. As reported in the account here given,

(*Concluded on page* 46)

First, **IT WAS PERFORMANCE**

..then **IT WAS COMFORT**

...and now **IT IS**

SAFETY

"We make the only motor that motes"
"It is built to run and does it"

These phrases from early automobile advertising aptly illustrate the emphasis placed upon ***performance*** during the first years of automobile manufacture. Later, following the introduction of the closed body, interest began to center in ***comfort*** and ***riding quality.*** Today the chief concern of the industry and the public is ***safety.*** And the increasing number of nighttime traffic accidents has focused attention on lighting equipment as never before. Automotive engineers appreciate the importance of better lighting equipment and that is why they are standardizing on Guide Multibeam Headlamps. They know that Guide lamps add greatly to the driving convenience and comfort of the modern car—that they make a car safer to ***drive*** and therefore more attractive to ***buy.***

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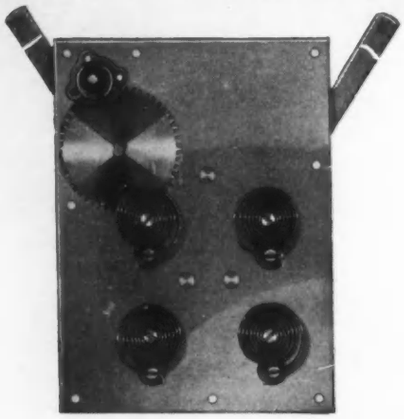

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NOTES AND REVIEWS

Concluded

models were used and the effect of front, rear and four-wheel drives, of axle loading and of the height of the center of gravity was investigated.

Windkanalmessungen an Modellen von Kleinwagen

Published in *Automobiltechnische Zeitschrift,* July 10, 1935, p 331. [L-1]

To determine the fundamental rules which should govern the body forms of high-speed small cars, models were tested in the wind tunnel of the Stuttgart engineering college. Three body types were included in the investigation, in the course of which about 300 measurements were made.

Project d'Etude pour la Voiture S.I.A. à 2 Places et 8,000 Francs

By A. Caputo. Published in *Omnia,* June, 1935, p. 18. [L-1]

The French society of automotive engineers is conducting a competition for the design of a two-passenger car to be sold for 8,000 francs or less. Suggestions are here advanced concerning the various qualifications and features to be incorporated in such a car, a review also being made of small cars of the past and present.

Comment on Fait les Essais de Voitures

By Henri Petit. Published in *La Vie Automobile,* June 25, 1935, p. 239. [L-1]

This magazine publishes from time to time reports of performance tests made by its staff on current passenger-car models. In this article is described the technical execution of these tests, the control methods and instruments being presented and explained.

Motors and Motoring (Mechanism, Maintenance, Repairs, Driving)

Second Edition. Published by E. & F. N. Spon, Ltd., London, and Engineers' Book Shop, New York City, 1935; 197 pp. [L-3]

A pocket size manual which the publishers claim contains all the information that the owner-driver needs to know concerning the mechanism of his car, its use, maintenance, disorders, repairs, and rules for driving.

Two New Processes That Bring Automotive Rustproofing Up-to-Date

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CROMODIZING

Provides the most perfect rustproof and paint preserving coating that can be applied directly to steel. A process that is low in cost—simple in operation—consistent in results.

Electro-Granodizing should be specified for head and tail lamps, hub caps, metal wheels, radiator grills, hardware, and other fine automotive parts—wherever the most perfect rustproofing is required.

Electro-Granodizing parts may be shipped or stored, without requiring any further treatment when they are ready to be painted.

Produces a surface that compares favorably with the best protective coatings now offered—the only rustproof surface that will not crack when bent or distorted. Paint has a better luster when applied over Cromodized steel.

Cromodizing is the lowest in cost of any rustproofing process available. ACP will guarantee that the cost of chemicals will not exceed a standard low rate per 100 sq. ft. of surface treated.

Cromodizing is a clean-cut, foolproof rustproofing method that is easily adapted to protecting any type of automotive part.

ACP Keeps Pace with the Industry

The experience and knowledge that 20 years of rustpreventing service provide are at the service of Automotive manufacturers.

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